CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN MCLEISH, DIRECTOR

Helium in Canada

BY

R. T. Elworthy

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

No. 679

Price, 20 cents.

CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

Helium in Canada

BY

R. T. Elworthy

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

No. 679

CONTENTS

CHAPER V

ILLUSTRATIONS

Photographs

Maps

INTRODUCTORY

The exigencies of the Great War gave rise to many remarkable scientific and engineering developments. Not the least of these has been the production of helium on a commercial scale in the United States. Ten years ago helium was considered a rare gas and almost a scientific curiosity—to-day over twenty-five million cubic feet has been extracted, and airships have been filled with it—the realization of what a German scientific writer in 1914 referred to as a Utopian dream.

Although the investigation of the possibilities of obtaining helium economically in large quantities was commenced in Canada in 1916 the greater resources of the United States both in supplies of rich helium-bearing natural gas and in the financial support forthcoming enabled them to accomplish the results set forth above.

The original survey of Canadian resources was carried out under the direction of Prof. J. C. McLennan of the University of Toronto in 1916 to 1919. Since that time further developments have taken place in the oil and gas fields of Canada and it seemed desirable to bring up to date our knowledge of the possible supplies of helium available, particularly as Canada is the only part of the British Empire where helium has been found.

The following report gives a brief account of the resources, together with details of the methods employed in analysis and extraction, and an outline of the progress that has been made in the United States. Some possible industrial uses of helium are also reviewed.

The results of this investigation show that the available supplies are insufficient to furnish the great volumes of helium that would be necessary to supply the commercial airships of five and six million cubic feet capacity that are now under construction in Great Britain. Whether or not other possible uses are of sufficient importance to warrant the extraction of smaller amounts of Canadian helium remains to be seen. A committee of the National Research Council of Canada has had the subject under consideration for some time and it is hoped that an experimental extraction station will again be put in operation to determine the most efficient processes to be applied to Canadian gases and to ascertain actual production costs on a commercial scale.

The results of the necessary preliminary work, a survey of the available sources, are presented in this report.

Acknowledgments

Col. R. B. Harkness, Commissioner of Natural Gas, Ontario, has greatly assisted in the preparation of this report by his advice and help and in the supply of much data regarding the Ontario gas fields. The officers of the Union Natural Gas Company and of the Dominion Natural Gas Company have helped most willingly in every way possible. In Alberta Mr. C. C. Ross, Chief Mining Inspector, and Mr. C. Dingman, Petroleum and Natural Gas Inspector of the Northwest Territories and

Yukon Branch of the Department of Interior, assisted in many ways. Mr. H. Pearson, President of the Canadian Western Natural Gas Company and Mr. Draper, Western Manager of the Imperial Oil Company, supplied much information and assisted in arranging for the collection of gas samples.

Much credit is due to R. J. Offord, Senior Laboratory Assistant, Mines Branch, who carried out most of the analyses and helium determinations and helped in the field work in Alberta. Miss D. M. Stewart, Research Assistant, Mineral Resources Division, rendered great help in the preparation and revision of the manuscript and in the preparation of the bibliographies appended to each section.

CHAPTER I

HELIUM AND ITS PROPERTIES

DISCOVERY

Helium was discovered[1] in 1895 by the late Sir William Ramsay, one of the most famous of British chemists and noted for his work on the rare gases of the atmosphere. He was struck by the discrepancies between the weights of equal volumes of nitrogen prepared chemically, and nitrogen separated from the air, which Lord Rayleigh observed in his study of the density of nitrogen, and the results of his experiments showed that the atmospheric nitrogen was heavier on account of the presence in it of a new inert gas which he isolated and called argon. Lord Rayleigh and Sir William Ramsay then separated larger quantities of this gas from air and studied its properties[2]. Its principal characteristics were its inert nature and its monatomic composition. It was found to be present in the atmosphere to the extent of one per cent.

Ramsay then sought for other sources of argon. His attention was drawn to some work carried out in 1889 by the late Dr. Hillebrand,[3] in which he found that an inert gas was given off from the uraninite mineral cleveite on boiling it with sulphuric acid. Hillebrand thought that this gas was nitrogen; 12 per cent of it certainly was. Ramsay repeated the experiment and examined the gas in a spectrum tube, expecting to see the argon spectrum. However, he was struck with the brilliancy of a yellow line which he could not account for, very close to the yellow lines D_1 and D_2, which are due to sodium, and he asked Sir William Crookes to carry out exact measurements of the wave length of this line. His determinations[4] showed that this line was none other than the D_3 line, only previously observed in the chromosphere of the sun during a solar eclipse in India in 1868 by Janssen, and afterwards shown by Frankland and Lockyer to be due to a new element in the sun which they named Helium from the Greek Helios.

This discovery of helium as a terrestial substance aroused much attention. Ramsay pointed out the probable existence of three more inert elements which would complete the family of these so-called "rare" gases, a prophecy which was wonderfully fulfilled in 1908, when he and Dr. Travers[5] obtained krypton, neon and xenon from the least volatile portions of a large quantity of liquid air.

During the next decade much research was carried out on the occurrences and properties of helium. It was found to be a constituent in small amounts of gases from mineral springs[6]; it occurred occluded in many

---

[1] Discovery of Helium, Chem. News, Vol. 71, p. 151, 1895, also Proc. Roy. Soc. London, Vol. 58, pp. 65–81, 1895. See also "The Gases of the Atmosphere" by Sir William Ramsay, published by Macmillan, 1915.

[2] "Argon, a New Constituent of the Atmosphere," Lord Rayleigh and William Ramsay; Proc. Roy. Soc. London, Vol. 57, p. 265, (1892.)

[3] Hillebrand, W. F.: U.S. Geol. Surv., Bull. 78, p. 43 (1893).

[4] Crookes, William.: Chem. News, Vol. 71, p. 151 (1895); also Vol. 72, p. 87 (1895).

[5] Ramsay and Travers: Proc. Roy. Soc., Vol. 62, pp. 316 and 437 (1898).

[6] See under Helium Occurrences.

minerals[1], and was present even in the atmosphere[2] to the extent of four parts in a million. In 1905, Cady and MacFarlane[3], investigating a non-combustible natural gas at Dexter in Kansas, found 1·84 per cent of helium in the gas. This led them to the examination of other natural gases from the same neighbourhood, and in most of them helium was found. Previous to this discovery, although helium was known to be widely distributed, it was always in such traces that it was regarded as a rare element. Even then helium was not obtained in commercial quantity.

PROPERTIES[4]

In spite of the difficulties of manipulation with the small quantities of helium available previous to 1917, its properties and physical constants were most thoroughly investigated. Before methods for its recovery from natural gas were established, the only method of obtaining helium was by heating or treating with sulphuric acid certain rare minerals and the cost of this gas was equivalent to about $1,500 per cubic foot.

Helium has several remarkable properties which make it of great interest to the scientist. It will be of considerable industrial value from the commercial viewpoint, particularly when larger quantities are freely available.

Helium is colourless and odourless, with a molecular weight of 4; hydrogen is the only substance known which is lighter in weight. The density of helium compared with air as unity is 0·1368 whereas that of hydrogen is 0·0696. This property, coupled with its non-inflammability, makes helium the ideal gas for filling balloons and airships.

It is only slightly soluble in water or other liquids, a property which suggests great possibilities for its industrial usefulness. Helium is an inert gas and, until recently, no combinations with any other elements were known or could be made. Now, under special conditions, very small amounts of a compound with mercury can be formed. It conducts heat better than any gas, with the exception of hydrogen, and this property may ultimately be turned to commercial advantage. Many observers have investigated its spectrum which is noteworthy for the brilliance and regular spacing of the lines, and their work has been the basis of many theories of atomic structure. On account of the relatively simple arrangement of the helium atom it has received much attention from the physicists. Another property that marks helium for distinction among the gaseous elements is its low boiling-point, which is 268·8° C. or 4·5° absolute. After ineffectual attempts to liquefy helium had been made by several experimenters, Kammerlingh Onnes[5] brilliantly succeeded at Leyden in 1908. Prof. J. C. McLennan[6] and co-workers at the University of Toronto have since made large quantities of liquid helium, and have carried on investigations of the properties of many substances when surrounded by a bath of liquid helium, which gives the lowest temperature attainable.

---

[1] Ramsay, W., Collie, J. N., and Travers, M.: Jour. Chem. Soc., Vol. 67, p. 684 (1895).
[2] Ramsay and Travers: Proc. Roy. Soc., Vol. 62, pp. 316 and 437 (1898).
[3] Cady and MacFarlane: Jour. Amer. Chem. Soc., Vol. 29, p. 1524 (1907); and Kansas Univ. Geol. Surv., Vol. 9, pp. 228–302 (1908).
[4] For complete description of properties see Textbook of Inorganic Chemistry, by J. Newton Friend, Vol. I, pp. 298–322; published by Charles Griffin, London, 1917.
[5] Onnes, Proc. K.: Akad. Wetensch, Amsterdam, Vol. II, p. 168 (1908); also Compt. rend., Vol. 147, p 421 (1908).
[6] An account of this investigation will be found in several papers in Proc. Roy. Soc., Canada, Third Series, Vols. XVIII, XIX, and XX, 1924, 1925, and 1926.

HELIUM AND THE RADIOACTIVE ELEMENTS[1]

One of the reasons why helium is of particular interest to the scientist and has been so closely investigated is because of its relation to the phenomenon of radioactive disintegration. The fact is well established that radium, uranium, thorium, and the other less known radioactive elements emit certain rays which have great penetrating power and are made use of in certain therapeutic processes. These rays, of which three kinds are known, the alpha, beta, and gamma rays, result from the actual breaking down of the atoms of the radioactive element. In the course of time the residue resulting from this breaking down is found to be a new element and actual transmutation of matter has taken place. This process of radioactive disintegration is very slow, the rate varying for each element.

Thus uranium slowly disintegrates giving radium; radium forms a series of products, eventually resulting in ordinary lead being formed. Rutherford, Soddy, and Ramsay[2] laid the foundations of these facts in a series of brilliant researches, and in the course of their many investigations it was shown that the alpha rays which were emitted by most of the radioactive elements were simply electrically charged helium atoms. After these had lost their charge they became ordinary helium gas. Therefore, the radioactive elements or any substances containing them are a source of helium. Subsequent research has shown that the radioactive elements are widely dispersed in the earth's crust. Knowing the rate of decay of these elements, the rate of formation of helium can be calculated, and it can be shown that in the course of geological ages a sufficient volume of helium can have been formed to account for the existence of most of the helium that is known to be present in natural gas in certain fields in the United States and Canada.

OCCURRENCES OF HELIUM IN NATURE

It has already been stated that helium is found occluded in certain rare minerals containing uranium, radium, thorium, or some other radioactive element. Such minerals as pitchblende, cleveite, fergusonite, broggerite, and monazite were the commercial sources of helium previous to its recovery from natural gas. Sir William Ramsay's researches on the rare gases of the atmosphere, showed that helium was present to the extent of four parts in a million. Investigations on the radioactivity of mineral-spring waters and the gases evolved from mineral springs proved that helium was a common constituent of these gases also. This subject has been very fully investigated by the French scientists, C. Moureu and Lepape.[3] One spring at Santenay gives off nearly 600 cubic feet of helium a year, mixed with larger volumes of other gases, and smaller amounts are evolved from certain other mineral springs.

Reference has already been made to the work of Cady and MacFarlane, who first observed the presence of helium in certain natural gases in Kansas. No particular attention was paid to this discovery at the time as

[1] For a complete discussion of radium and radioactive substances, *see* Rutherford, E.: Radioactive substances and their Radiations; Cambridge University Press, London, 1913. Russell: Introduction to Chemistry of Radioactive Substances; Murray, London, 1922. For data *see* International Critical Tables, Vol. I; McGraw-Hill, 1926.

[2] Ramsay and Soddy: Proc. Roy. Soc., Lond., Vol. 72, p. 204 (1903).

[3] The subject is fully treated in a lecture given by Prof. C. Moureu before the Chemical Society, London. "L Gaz Rares des Gaz Naturels," Trans. Jour. Chem. Soc., Vol. 123, part 2, pp. 1905–1947 (1923).

no special need for large quantities of helium had arisen, but, as soon as the exigencies of the war brought forward the desirability of obtaining commercial supplies of this gas, investigations were commenced by the British and later by the United States Governments with the result that, to-day, the sources of helium on the North American continent have been thoroughly studied so far as the present known natural gas fields are concerned, and in the United States over twenty-five million cubic feet have been extracted from natural gas in Texas.

THE ORIGIN OF HELIUM IN NATURAL GAS

The origin of the helium found at least in traces in so many natural gases and minerals is a very interesting scientific problem. The relation of helium to the radioactive elements such as uranium and radium has been briefly referred to, as well as Sir Ernest Rutherford's[1] investigations in which he proved that the alpha rays emitted by these elements undergoing disintegration are charged helium atoms moving at a high velocity, which when the charge is neutralized become ordinary atoms of gaseous helium.

A study of the distribution of these radioactive elements in the earth's crust investigated by many observers and particularly by Joly[2] who has shown that these elements are distributed throughout the rocks composing the surface of the earth with great uniformity, though in small amounts.

Knowing the amounts of the radioactive elements in a definite volume of the earth's crust and the rates of disintegration the quantity of helium formed in a definite period of time can be calculated. In this way Rogers estimated that approximately 0·5 cubic feet of helium per annum per cubic mile is the average figure, and calculations of the probable helium content of a natural gas reservoir based on this estimate are in accordance with the facts.

The modern theories advanced to account for the collection of and for the storage of natural gas and petroleum in domes and anticlines, carried from the places where they are formed, by the movement of underground water through porous strata until they are trapped in the higher formations from which there is no chance of further migration, are in accordance with the theory. The natural gas would have a sweeping out action on the minute quantities of helium already existent in the rocks.

There can be no doubt that the helium formed by the radioactive elements present in all rocks does leak away and migrate to the surface thus accounting for the helium present in the atmosphere. Such leakage, too, must represent by far the largest amount of the helium so formed.

The great differences in distribution of helium in the various natural gas fields must still be explained. Some would suggest that there must have been a local concentration of radioactive elements in these districts where the richest gases are found. More reasonable explanations are that there is some particularly impervious strata which would favour retention of helium. Such a favourable structure as S. C. Lind suggests is a capping of shale with sufficient clay to afford a gas seal. So far, neither in the United States nor in Canada does any relation between certain geological horizons and rich helium-bearing gases seem to hold. Unfortunately very

[1] Rutherford and Royd: Phil. Mag., Vol. 17, p. 281 (1909).

[2] Joly, J.: Radioactivity and Geology, Constable, London (1909). *See also* International Critical Tables, Vol. I, pp. 372–381 (1926).

little data have been collected on the nature and properties, porosity, density, composition, radioactivity, etc., either of the gas sand or of the capping in the richer helium-bearing natural gas wells.

An alternative theory put forward by Rogers[1] is that the helium is of primordial origin and that it has no connexion with radioactivity. The arguments that are advanced to support the theory have some weight but in view of the more recent proofs that there is sufficient concentration of radioactive elements in the earth's crust to provide the quantity of helium that is known to exist in the atmosphere and in rich helium-bearing natural gas reservoirs it does not seem so satisfactory an explanation as the previous one.

HISTORY OF COMMERCIAL DEVELOPMENT

The possibility of obtaining helium in sufficient quantity to fill British airships and balloons during the war was the suggestion of Sir Richard Threlfall in England in 1915. As a result of his representations to the Admiralty, Prof. J. C. McLennan of the University of Toronto was requested to determine if helium occurred in Canadian natural gas and if it could be separated.

Early in 1916, representative samples of natural gas from most of the producing fields in Canada were examined. The results of the survey showed that there were two places in the Dominion where an experimental extraction station might be established, at Hamilton in Ontario and at Calgary in Alberta. Further examination of gases from all parts of the British Empire did not disclose the existence of any additional possible commercial sources. The results of the survey were subsequently published.[2]

In 1918 a small experimental extraction station was set up near Hamilton, Ontario, in which gas from the Blackheath field was treated. Preliminary experiments with a modified Claude oxygen column proved that helium of a high degree of purity could be obtained. In the latter part of the year on account of the falling-off in the supply of natural gas from this field and the greater suitability of the gas from the Bow Island field in Alberta, the experimental station was moved to Calgary, where after the Armistice, from December 1, 1919 to April 17, 1920, a series of trial runs was carried out.

In all about 60,000 cubic feet of helium of 60 to 90 per cent purity was separated. The plant was closed for lack of further financial support.

THE UNITED STATES DEVELOPMENT[3]

As soon as the United States entered the war Dr. R. B. Moore and Col. G. A. Burrell of the U.S. Bureau of Mines, knowing of the British interest in helium and being acquainted with the work of Cady and MacFarlane on the helium content of Kansas natural gases, were able to convince the United States Government of the great value of the possibilities of the

[1] The origin of helium in natural gas is fully discussed by G. Sherburne Rogers in U.S. Professional Paper 121, pp. 60–68, 1920, and more recently by S. C. Lind in. The Origin of Terrestial Helium and its Association with Other Gases. Proc. Nat. Acad. Science, Vol. 11, No. 12, pp. 772–779 (1925). This section has been largely taken from these papers.

[2] McLennan, J. C. and associates: Report on some Sources of Helium in the British Empire, Mines Branch, Dept. of Mines, Canada, No. 522 (1920).

[3] The most recent and complete account is R. B. Moore's Perkin medal address. Ind. and Eng. Chem., Vol 18, pp. 198–211, Feb. 1926. *See also* Moore, R.B.: Jour. Frank. Inst., Vol. 191, pp. 145–199, Feb. 1921, and bibliography .

commercial production of helium, and an extensive investigation was commenced. Surveys by the U.S. Bureau of Mines and the Geological Survey showed the existence of several rich helium-bearing natural gas supplies. Large-scale extraction plants were experimentally operated by the Linde Air Products Corporation, by the Air Reduction Company and by the U.S. Bureau of Mines using the Jeffreys-Norton process. Such success was obtained that the first large supply of helium was awaiting shipment to France when the Armistice was declared.

Since that date great progress has been made. From the results obtained in the three extraction plants it was decided in 1920 that the Linde process was the most successful and a plant to treat five million cubic feet of natural gas a day, was erected at Fort Worth in Texas. From April, 1921, to the present day, this plant has been operated with but few shutdowns. The different stages of the process have been again and again improved and the cost of extraction has been reduced from the initial cost of $500 per thousand cubic feet down to $24 per thousand cubic feet in June, 1925. The plant has been operated by engineers of the Linde Air Products Company in collaboration with the U.S. Navy authorities.

The United States Bureau of Mines meanwhile carried on investigations of all kinds on the physical constants of the lower hydrocarbon gases and of gas mixtures at low temperatures, obtaining data so necessary for the efficient design and operation of the extraction plants. Many other scientific and industrial problems were worked out and processes for repurification of helium after contamination in the bags of the airships were devised, and both stationary and mobile plants were erected and operated.

A very complete and interesting account of the process of extraction and costs of production of helium was given in a paper read before the American Society of Naval Engineers by Lieut. Commander Z. L. Wicks.[1] High pressure storage tanks have been built to hold the surplus supplies of helium at the large airship stations. Cylinder railway cars capable of holding 200,000 cubic feet, have been the means of greatly reducing the cost of transport of helium from the extraction plant at Fort Worth, in Texas to the airship station at Lakehurst, New Jersey, and other points.

[1] Jour. Amer. Soc. of Naval Engineers, Vol. 37, No. 4, Nov. 1, 1925.

CHAPTER II

HELIUM SOURCES IN OTHER COUNTRIES

It has already been stated that practically the only sources of a large commercial supply of helium are natural gases containing this gas in sufficient quantity to allow of its economic extraction.

Although very few countries have no occurrences at all of natural gas, the greatest resources in the world are found on the North American continent. Comparatively little search has, therefore, been made in other parts of the world for helium because the available supplies of natural gas are small. The following paragraphs briefly mention those occurrences on record.

AUSTRALIA AND NEW ZEALAND

Although small flows of natural gas have been found in New South Wales and in North island, New Zealand, no commercial developments of gas have been established. The Australian gas so far as is known has not been tested. A number of samples from New Zealand were examined[1] in 1918. They contained only from 0·001 to 0·065 per cent helium.

JAPAN

Thirteen samples of natural gas in Japan have been investigated,[2] values of 0·002 to 0·007 per cent helium being found. Only one sample, the Yamagata gas, gave the higher result of 0·2 per cent. Nothing is known of the helium content of natural gas in China.

PERSIA

Natural gas which is obtained in great quantity together with oil from the Maidan-I-Naftun field in Persia has been found to contain no helium. This gas is remarkable for the large amount of hydrogen sulphide it contains (up to 13 per cent).

RUSSIA

No records of the helium content of natural gas in the oil fields adjoining the Black sea are known.

TRANSYLVANIA

The natural gas fields in Transylvania are the greatest producers of natural gas in Europe and the most modern methods of utilization are applied, much of the gas being used for chemical manufacture. Czako[3] carried out investigations of the helium content of gases for this region, finding them to contain less than 0·01 per cent.

GERMANY

A few gases from bore-holes, mines, and springs have been examined and small percentages of helium found in them.

[1] Mines Branch, Dept. of Mines, Canada, Rept. 522, p. 57.
[2] N. Yamada, Jour. Chem. Soc., Japan, Vol. 43, p. 884, (1922).
[3] Czako, E.: Zeit. anorg. Chem., Vol. 82, pp. 261-268 (1918).

The chief potential source of helium in Germany is from the monazite sands used for the preparation of the cerium and other rare earth metals used in the incandescent mantle industry.

ITALY

A number of Italian natural gases were discovered to contain traces of helium, some years before the outbreak of the great war. One sample of gas from a well at Pisa, however, tested in 1918, contained no helium at all.

FRANCE

Very careful studies[1] have been carried out on the rare gases present in mineral spring gases, in the mine gases and in gas from bore-holes, and the relations between the quantities of the various gases present to the radioactivity of the sources were carefully investigated. No large commercial sources were found, although appreciable quantities of helium are given off annually from certain springs.

GREAT BRITAIN

The only well which produced natural gas in any quantity in England is at Heathfield, Sussex. The well is now exhausted. Gas from it, tested in 1918, contained 0·21 per cent helium[2]. Bath Mineral Spring gas contained 0·16 per cent.

SOUTH AMERICA

The only natural gases from South America that are known to have been examined are a number of samples taken from wells in Peru which were tested in this Department in 1925. No trace of helium was found in them.

UNITED STATES

The United States possesses by far the largest resources of natural gas in the world and the annual output which in 1924 was approximately 1,300 billion cubic feet is far in excess of the production in any other country. Canada comes second with a production of about 15 billion cubic feet. It is readily understood therefore why so much attention has been paid to helium resources in the United States, particularly as the original work of Cady and MacFarlane showed the possibilities of rich helium-bearing gases occurring in other parts of the country than Kansas. All the gas fields in the United States have been examined and much data have been collected on the available supplies of helium. An account of the early work was published in a most valuable report[3] which gives a very complete account of helium, its properties, occurrences, theories of origin, and the United States resources.

Since then, the results have been kept confidential, although it is known that further rich sources have been found and that every year some six or seven hundred million cubic feet goes to waste in the natural gas which is not treated for the recovery of helium. Much of this helium could not be economically recovered but with only a few plants at least 50 million cubic feet a year could be obtained.

---

[1] Moureu: Jour. Chem. Soc. Trans., Vol. 123, Pt. 2, p. 1905 (1923).
[2] Mines Branch, Dept. of Mines, Canada, Rept. 522, p. 65.
[3] Rogers, G. Sherburne: Helium-bearing Natural Gas. U.S. Geol. Surv. Prof. Paper No. 121 (1921).

The following brief account of the main helium-bearing gas fields in the United States is taken from several reports and papers[1] that have been published in the last few years.

The main helium resources occur in the Texas, Mid-Continent and Appalachian natural gas fields. In Texas the chief gas field is at Petrolia and it has been calculated that there was over 1,000 million cubic feet of helium in the original gas reservoir. However, the field has been drawn upon for a number of years and is almost exhausted. The Nocona field in this area is estimated to contain from three-quarters to two billion cubic feet of helium as yet untouched.

In the Mid-Continent field the chief supplies of rich helium-bearing gas occur in El Dorado, Augusta, Dexter, Otto and Rogers fields in the state of Kansas. These are all small fields and partly exhausted. The richest gases, containing from 1·0 to 1·5 per cent, flow from sands 300 to 600 feet deep. The amount of helium obtainable from the fields in this area is calculated to be about 10 million cubic feet. In the Appalachian field, Vinton county, Ohio, there is an estimated supply of 75 million cubic feet from 200 small wells 1,700 to 2,400 feet deep, the gas from which contains only 0·4 per cent helium.

Another rich helium-bearing gas field has recently been discovered in Mery county, Utah, in the Rocky Mountain area. The reserves in this field are about three billion cubic feet helium. The area is closed, by Presidential action, to public settlement, location, sale or entry.

Further details of these fields are given in the publications already referred to. The United States authorities state that it would be quite possible to extract yearly 50,000,000 cubic feet of helium from gas which is being regularly used and this quantity could be greatly increased in case of emergency. They consider gas is commercial in grade if it contains 0·5 per cent helium with sufficient volume to justify commercial operation of a separation plant. The Petrolia gas which is treated in the Fort Worth plant contains 0·94 per cent helium. A number of other localities in the United States are known, as already described, where gas containing over 0·5 per cent helium can be obtained in commercial quantity.

---

[1] Rogers, G. Sherburne: Helium-bearing Natural Gas, U.S. Prof. Paper No. 121 (1921).
Moore, R B.: Helium, a National Asset, Mining and Metallurgy, Aug. 1923.
Bottom, R. R.: Helium Sources and Extraction Processes. Oil and Gas Journal, Vol. 23, p. 20, Nov. 20, 1924.
Wicks, Z. W.: The Importance of Helium to the Petroleum Industry and the United States; Natural Gas, Vol. 6, pp. 10–13, Jan. 1925.

CHAPER III

THE INVESTIGATION OF HELIUM SOURCES IN CANADA

The preliminary survey made by Prof. J. C. McLennan in 1916-1918, showed that helium occurred in most natural gases in Canada. Very little information existed, however, of the helium content of gases from pipe-line systems in the various fields and of the most suitable locations where the maximum quantities of gas were available for treatment and at which extraction plants might be erected. Such data had been completed for the Bow Island field, Alberta when the Calgary helium extraction plant was installed but since that time owing to the partial exhaustion of this field and to the opening up of new fields which now supply the greater part of the gas used in Calgary, the situation has changed.

In consequence, too, of the activity in drilling for petroleum in Alberta many new flows of natural gas have been opened up. Similarly in Ontario new drilling has been in progress, both in the older gas fields and in new areas, and it seemed desirable to carry out a thorough survey in conjunction with a comprehensive investigation of the natural gas resources of Canada.

The following report gives a concise account of the results of this investigation. A brief outline of the field work and of the methods employed, followed by more detailed descriptions of the methods of analysis, particularly of the helium content of the gases precedes the results obtained.

FIELD WORK

The field work has occupied the greater part of the field seasons of the past three years. In the fall of 1923 a survey was made of the gas fields in central and southern Alberta. In 1924 work was carried on in June and July in Ontario; and in September and October in northern Alberta, and examinations were made of new wells in central Alberta. The gas fields of Ontario were the subject of a more intensive examination in 1925 and the Stony Creek field in New Brunswick was also visited.

At the various wells chosen as representative of the fields, determinations were usually made of the open flow, rock pressure, gasoline content, and specific gravity of the gas. Samples for analysis were collected and information was obtained of the history of drilling, depth and log of well, and of any other matters that seemed of importance.

Duplicate samples for analysis were collected in one-gallon glass bottles, usually by water displacement, though for comparison some samples were taken by air displacement by allowing the gas to pass through the bottle for at least five minutes. Subsequent analyses of samples collected by both methods proved that the water displacement method was the more reliable. Helium is so slightly soluble in water that no appreciable error is caused by this method of sampling. Where larger quantities of gas were required and when the wells were large and under

high pressure, samples were taken in small gas cylinders. These were washed out four or five times by alternately filling with the gas to well pressure and blowing off and were finally filled at a pressure usually over 500 pounds per square inch.

LABORATORY INVESTIGATIONS

All gas samples were examined quantitatively for helium, and their density measured. Complete analyses of the various constituents were made only on representative samples from the individual fields or from noteworthy wells.

The Determination of Helium[1]

The chief constituents of natural gas are usually methane, ethane, and nitrogen with smaller amounts of carbon dioxide, oxygen, helium, and the higher hydrocarbons. Hydrogen has seldom or never been found in natural gas. The hydrocarbons, methane, ethane, etc., as well as carbon dioxide and oxygen, can be removed by burning with oxygen and absorbing the carbon dioxide so formed in potash and the oxygen in pyrogallol solution, or by liquefying them by cooling with liquid air or oxygen. The residual gaseous mixture of nitrogen and helium can then be separated in any one of three ways, viz., by sparking the nitrogen in the presence of oxygen, by circulating the mixture over heated calcium metal until further contraction in volume ceases, or by removing the nitrogen by absorption in activated charcoal cooled to liquid air temperature.

These methods are fully described in the literature. The most suitable and rapid method for laboratory use is the latter one.

APPARATUS

The apparatus used for the helium analyses is illustrated in Plate I.

It consists essentially of a drying-tube A containing calcium chloride, a condensation tube B, about 20 cms. long and 2·5 cms. in diameter, reduced to 1·2 cms. diameter at the end and graduated so that the volume of liquefied gas can be measured, a Toepler pump C, and mercury manometers D and E. A tube F, 20 cms. long and 2·5 cms. in diameter, containing about 20 grammes activated charcoal, is connected as shown in the plate, with a spectrum tube G, attached through a mercury trap H, and a Toepler pump J, to the final burette K, for measuring the volume of the helium separated. This burette K, is 0·5 cms. in diameter and 60 cms. long. It has a volume of 5 cubic cms. and is graduated in hundredths of a cubic centimetre. On account of the narrow bore of the tube the helium has to be pumped first into the reservoir L, and then run into the top of the burette K, through the trap. Another charcoal tube M is joined up through the tube and mercury trap N, so that the helium from the burette can be passed into it, given a second purification and then pumped around through the spectrum tube back into the burette and re-measured.

[1] Mines Branch, Dept. of Mines, Canada, Rept. 522, pp. 22–27.
U.S. Geol. Surv., Prof. Paper No. 121, pp. 41–42, (1921).

A gas analysis apparatus P, is included in the set-up, so that the arrangement could be used to make analyses of the hydrocarbon constituents by partial liquefaction and fractionation. Other essential pieces of apparatus are the aspirators Q, of 2·5 litres capacity to hold the sample, the balance R, sensitive to 1 gramme, the thermos bottle S, the spark coil T, the tubular electric furnace V for heating the charcoal tubes after analyses, and the mercury trough W for transferring the helium obtained from the measuring burette to the storage tube X.

The apparatus is all sealed together and the various sections are separated by well-ground glass taps.

PROCEDURE.

The whole apparatus is first thoroughly exhausted and tested to see that there are no air leaks. Thermos bottles containing liquid air or oxygen are then brought up around the condensation tube B, and the charcoal tubes F and M. In a few minutes a high vacuum is obtained and the spectrum tube will show only a green phosphorescence or will not allow any discharge at all. Readings of the manometers D and E are taken.

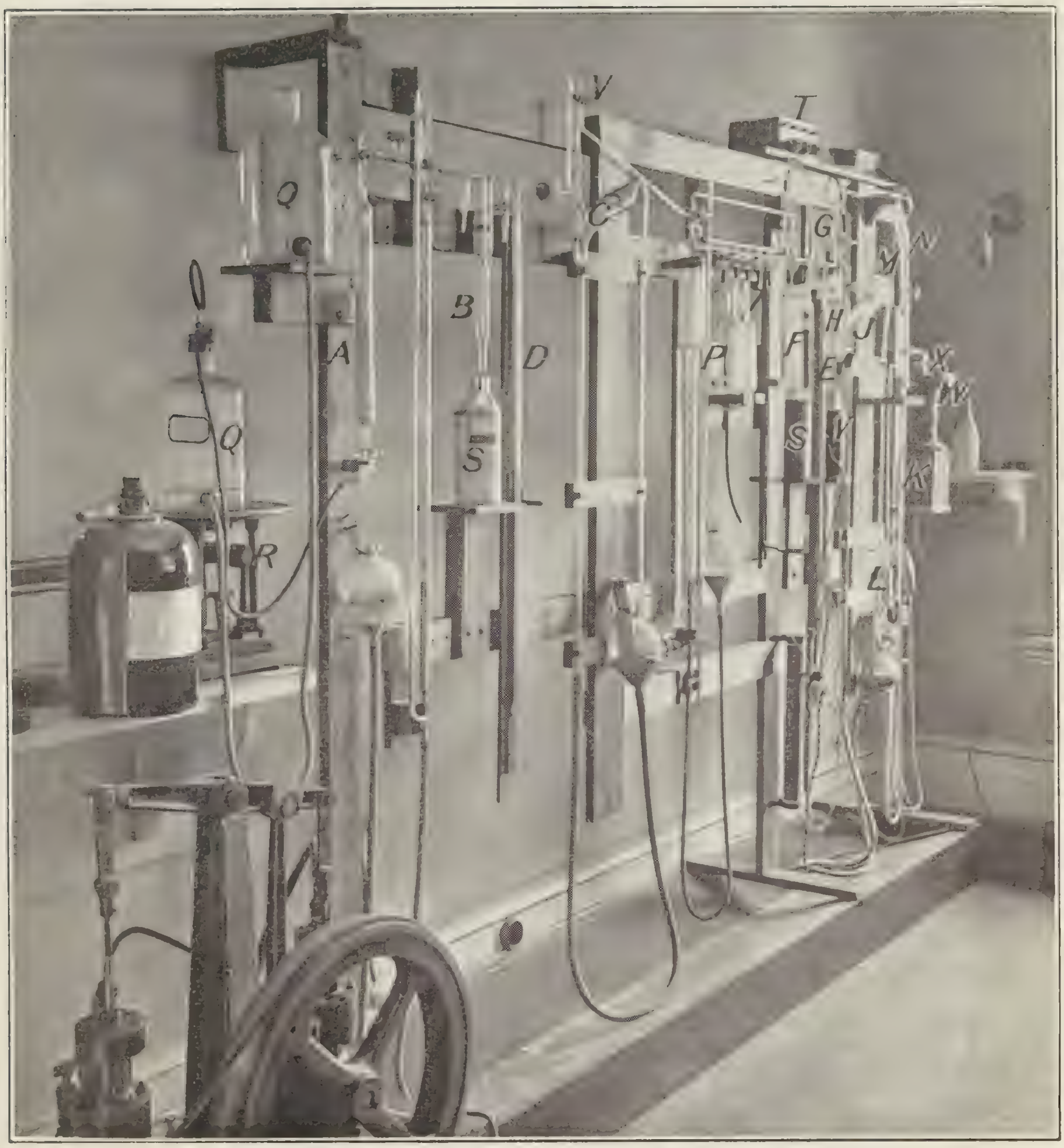
Meanwhile gas is allowed to fill the drying tube A up to the top tap. The aspirator containing the sample is weighed, the second aspirator being held in such a position that the gas is at atmospheric pressure. The sample is then allowed to pass slowly into a condensation tube B, the tap V being closed. Usually a volume of about one or two litres of gas is used. The top drying-tube tap is closed, the gas in the aspirator and drying-tube brought to atmospheric pressure and the aspirator on the balance again weighed. The weight of water which has run in, is a measure of the volume of sample used.

The manometer D, is read when equilibrium between the liquefied and unliquefied constituents of the gas mixture is attained. The difference between the initial reading and this reading affords an approximate measure of the volume of nitrogen and helium present. The volume of condensate is also recorded, by observing it when the thermos flask is removed for a few moments.

When equilibrium is attained once again the second step in the process can be taken, that of transferring the uncondensable gases to the first charcoal tube F.

This can be done in either of two ways, by pumping these gases by means of the Toepler pump C into burette P and subsequently passing the gases into charcoal tube F, or by opening tap V, for a few seconds and so allowing the gases in B and the connecting tubes to pass over into charcoal tube F, which is at a higher vacuum. If this is repeated three or four times it will be found that all the nitrogen and helium are washed out by part of the gaseous methane which vaporizes. The vapour pressure of liquid methane at temperatures between $-185°$C. and $-190°$C. is about 7 cms. mercury pressure and as gas is removed liquid methane will evaporate to maintain this pressure. Frequent tests have shown that this method of transferring the nitrogen and helium to the charcoal tube is as efficient as pumping them over and it has the advantage of being quicker.

After a few minutes when the charcoal has absorbed all the gases but helium, the manometer E is read. The spark-coil key is depressed and the



Helium analysis apparatus

spectrum of the residual gas is observed in G. After a little experience it can be told at once by the appearance of the discharge if all the nitrogen has been removed. Pure helium gives a brilliant yellowish orange discharge. Observation with a spectroscope should be made to verify the purity of the helium. Unless the charcoal has been used for a number of determinations and is becoming saturated with nitrogen, or unless a slight leak has developed, there should be no difficulty in obtaining pure helium as shown by its spectrum. It would be desirable to use a spectrograph at this point, and obtain a photographic record of the helium though this has not been done in our work so far.

The U-tube H should be surrounded by a thermos flask containing liquid air to prevent mercury vapour entering the spectrum tube.

The helium is then pumped by the Toepler pump J into the reservoir L until the charcoal tube, spectrum tube, and connexions are completely exhausted and a hard vacuum is obtained. The gas is then transferred into the measuring burette by opening the tap and raising the mercury reservoir attached by rubber tubing to the bottom of L, and after bringing it to atmospheric pressure, by means of the mercury reservoir to which the burette and manometer by its side are connected, the volume is read.

It is seldom necessary to re-purify the sample, although it can readily be done by transferring it from the burette into the charcoal tube M, when after allowing sufficient time for the impurities to be taken up by the charcoal, it can be allowed to flow into the spectrum tube, its spectrum observed and then pumped back into the reservoir and thence into the burette for re-measurement. This procedure has been frequently followed and with few exceptions the second reading checked with the first with a difference of a few thousandths of a cubic centimetre, the slight discrepancy being probably due to the retention of very small amounts of helium by the charcoal. Since the volume of the sample under known conditions of temperature and pressure, and the volume of helium also under known conditions of temperature and pressure are known the percentage can be easily calculated.

The data obtained in a typical determination follow:—

Sample from Simcoe, Ontario, Main pipe-line No. 25.
Date of collection, July 9, 1924.
Date of analysis, July 23, 1924.
Barometric pressure 754·0 mm. Temp. 26·2°C.

Vol. of gas used............Wt. aspirator	Test 1 Grms.	Test 2 Grms.
Before......................	1,468	2,206
After......................	2,206	3,355
Difference..................	738	1,149

Gauge Readings

—	Condensation tube				Charcoal tube			
	After sample is let in		After drawing nitrogen off		Before letting nitrogen in		Before pumping off helium	
	Reading	Pressure	Reading	Pressure	Reading	Pressure	Reading	Pressure
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Test 1..........	608 192	754 416	737 54	754 683	814 60	High vac.	811 63	754 748
	416	338	683	71	754		748	6
Test 2..........	613 186	754 427	732 58	754 674	814 60	High vac.	810 64	754 746
	427	327	674	80	754		746	8

	(1)	(2)
Spectrum..	brilliant	brilliant
State of vacuum after pumping off helium.......	hard green	hard green
Volume helium..................................	2·88 c.c.	4·50 c.c.
Volume sample..................................	738·0 c.c.	1149·0 c.c.
Percentage of helium...........................	0·390	0·392

Condensate in liquefaction tube

	(1)	(2)
	liquid, 1·0 c.c. vol.	liquid, 1·5 c.c. vol.
	(none left at room temperature)	
Smell..	sweet	sweet

Specific gravity

	(1)	(2)
Wt. of density bulb exhausted...........................	10·7555	10·7565
" " filled with air.........................	11·0540	11·0536
" " " gas.........................	10·9513	10·9523

Specific gravity = $\frac{0 \cdot 1958}{0 \cdot 2978} = 0 \cdot 654$

With the foregoing arrangement of apparatus, using a relatively small sample of gas and being able to measure as little as 0·005 c.c. of helium, the method is rapid and accurate. An analysis can be made in about half an hour and good checks on duplicate samples can be obtained.

With the addition of the measuring burette Z, the apparatus is suitable for analyses of all kinds of gaseous mixtures containing helium.

Other Methods for the Determination of Helium

The method described above is the most satisfactory for determining helium in natural gases or in gas mixtures in which it occurs in small amounts. For helium-nitrogen, helium-air, helium-methane mixtures other methods are available and will be briefly referred to.

THERMAL CONDUCTIVITY METHOD

This method, originally developed in Germany, is based on the change in resistance of a heated platinum wire forming one arm of a Wheatstone

bridge, when exposed to a gas mixture containing a constituent which has a greater or less heat conductivity than a standard gas surrounding the corresponding arm of the bridge. In the early stages of the war Prof. G. A. Shakespear of the University of Birmingham developed an instrument based on this principle for measuring the purity of hydrogen in balloons and for detecting small amounts of hydrogen in air. This instrument was adapted by Mr. V. F. Murray[1] for measuring helium in gaseous mixtures in the Admiralty Physical Laboratory in London, 1917-1919. About the same time Messrs. P. E. Palmer and E. R. Weaver[2] of the United States Bureau of Standards developed a somewhat similar instrument and their work has greatly extended the possibilities of this method of gas analysis for all types of gas mixtures of industrial importance. On account of the high thermal conductivity of helium, this method is of particular value for gases containing helium. A field method of determining helium in natural gas could readily be developed using the conductivity principle. The principle is invaluable in helium separation processes and instruments have been constructed by the United States Bureau of Standards to give automatic continuous records of the helium content of the various gas mixtures being treated in the United States Government helium extraction plant at Fort Worth, Texas, and in the various repurification units.

INTERFEROMETER METHOD

The interferometer method is more particularly adapted for the measurement of small amounts of helium in air, or in a mixture, the constituents of which are known. The method has been thoroughly worked out for hydrogen-air mixtures[3] and on account of the low refractive index of helium a similar procedure proved as satisfactory for helium-air[4] mixtures. This method, however, is limited in its application and is not so useful as the condensation method or the thermal conductivity method.

DENSITY METHOD[5]

Where the amount of helium is required in a simple mixture of which the constituents are known, particularly when helium is the preponderating constituent, the measurement of density with an Aston micro-balance, an Edwards gas-density balance or even a gas-density bulb will enable the amount to be calculated. For a mixture of helium and two other gases the density of the mixture and the percentage of one of them must be known to determine the percentage of each — assuming the qualitative composition is known, of course. This method has been used in determining the purity of helium in extraction processes.

Gas Analysis[6]

The determination of the other constituents of the natural gas samples was carried out by the ordinary methods of absorption for carbon dioxide

[1] V. F. Murray: Proc. Roy. Soc., Can., Third Series, Vol. XIII, Sec. III, pp. 27-35 (1919).
[2] Palmer, P. E. and Weaver, E. R.: The Thermal Conductivity Method for the Analysis of Gases, U.S. Bur. of Stan. Tech. Paper No. 249 (1924).
[3] U.S. Bureau of Standards, Tech. Paper No. 113, 1918, gives many references.
[4] McLennan and Elworthy: Proc. Roy. Soc., Can., Third Series, Vol. XIII, Sec. III, pp. 19-25 (1919).
[5] Mines Branch, Dept. of Mines, Canada, Rept. 522, p. 69 (1920).
[6] For complete discussion *see:* Sampling and Examination of Mine Gases and Natural Gas. U.S. Bureau of Mines Bull. No. 197 (1926).

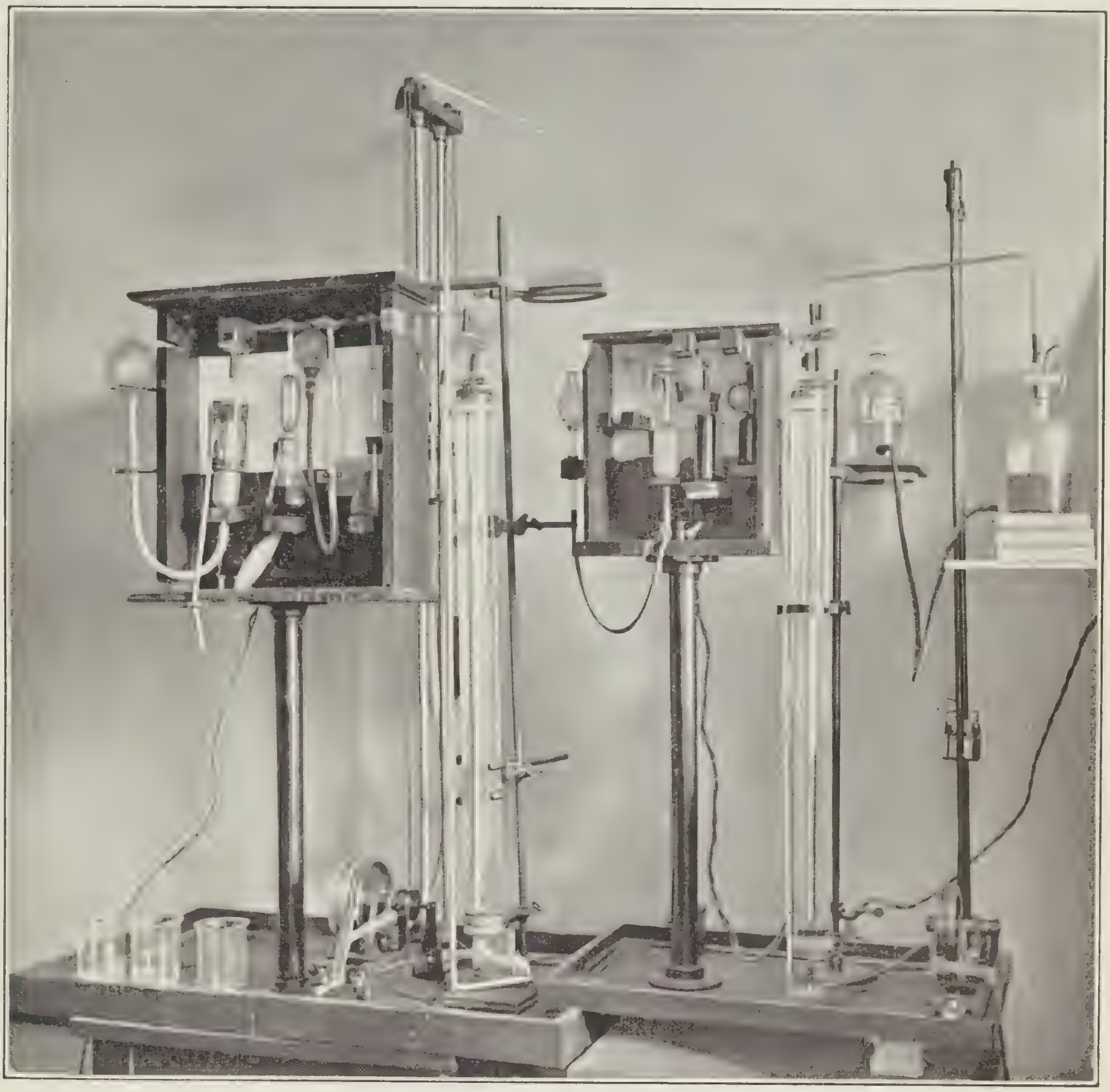
and oxygen followed by combustion of the hydrocarbons after the addition of a measured volume of oxygen. A modified Orsat apparatus, as developed by the United States Bureau of Mines,[1] was used.

Plate II illustrates the apparatus used.

It was found that much time could be saved by using one set-up for the determination of carbon dioxide and oxygen and a second apparatus for the combustion analyses. The use of winches for hoisting and lowering the mercury reservoirs greatly facilitated the analysis.

All the apparatus used both for helium determinations and for gas analysis with the exception of the graduated burettes were made in the Department's workshops.

[1] U.S. Bureau of Mines, Tech. Paper No. 320 (1925).



Gas analysis apparatus

CHAPTER IV

NATURAL GAS FIELDS IN CANADA

Natural gas has been found in commercial quantity only in the provinces of Alberta, Ontario, and New Brunswick. The petroleum and natural gas resources of Canada have been the subject of previous investigations by the Mines Branch, chiefly from the economic viewpoint, in 1912-1913 and in 1922-1925; and by the Geological Survey, from the geological standpoint, since its establishment. Several reports have been published both on the geology of the oil and gas fields and on their economic utilization. A list of the main reports is given in the bibliography.

ALBERTA

The main gas fields in Alberta lie in the south and central parts of the province and are shown on the accompanying map. Natural gas is found in the northern part also but, owing to the sparsely settled nature of the country and the difficulties of transportation, exploratory drilling has been carried on only along the banks of the Peace and Athabaska rivers. In almost every district in Alberta where wells have been drilled the desire has been to find oil and only in a few fields has the opening up of good gas wells been the main object. The gas fields lie east of a line joining Calgary and Edmonton — the Turner Valley field, 40 miles southwest of Calgary being the one exception. The four most developed fields are situated near main railway lines; the Medicine Hat and Bow Island fields on the Canadian Pacific railway and the Wainwright and Viking fields on the Canadian National line. The gas from these fields is used for domestic and industrial heating and lighting; Medicine Hat gas for the city of Medicine Hat; Bow Island and the Turner Valley gas for Lethbridge, McLeod, and Calgary; and Viking gas for Edmonton. The total consumption reported in 1924 was 7,100,000 M. cubic feet and in 1925, 8,998,931 M. cubic feet. This quantity is more than 50 per cent of the total consumption in Canada and it is increasing yearly.

The Peace River Field[1]

The Peace River field in which wells have so far been drilled covers an area half a mile in width on each side of the river and stretching from the town of Peace River to a point about 30 miles down stream. The first well was drilled by the Peace River Oil Company in 1916 on L. S. 4, sec. 31, tp. 85, range 20, west of the 5th meridian. During the following four or five years, the district experienced a small oil boom and a number of wells were drilled about 15 miles down the river and at Peace River itself. None of these wells produced oil in commercial quantity and after a short time most of them were abandoned and no further drilling was done. The costs of drilling were very great, mainly on account of the difficulties of transportation. Considerable money has been expended in the efforts to find oil in this neighbourhood and there has been practically no return for this expenditure, as not even large supplies of natural gas are available at the

[1] A fuller account of this field is given in "Invest. Min. Res. and Mg. Ind., 1924," p. 103, Mines Branch, Dept. of Mines, Canada.

present time. One of the greatest handicaps has been the difficulty experienced in shutting off the water.

Transportation

After the completion of the Edmonton, Dunvegan and British Columbia railway in 1916, the Peace River district became easily accessible from Edmonton. The distance by rail from Edmonton to Peace River is 310 miles and trains run twice a week.

Supplies and drilling machinery, casing, etc., have to be transported from Peace River down the river by barge. The current varies from about 8 miles an hour at high water to 4 or 5 miles at low water. However, there are no rapids or swift water until Vermilion chutes are reached, a distance of 250 miles.

Geology

The geology of both the Peace and the Athabaska River valleys has been investigated by R. G. McConnell in 1892, and by F. H. McLearn in 1917-1919, and reported on in several publications.[1]

The gas reservoirs are found in sandstones which compose the lower part of the Loon River formation. The standstones are found at depths between 850 and 1,000 feet and are commonly separated by thin shale beds. McLearn states that it is probable that these sandstones thin out towards the north, as near Vermilion chutes, where the lowest strata of the Loon River formation outcrops, the sandstone is entirely replaced by shale.

Character of Gas

Although a heavy oil has been found in small amounts in most of the wells drilled, the gas carries no gasoline. The main constituents are mainly methane, about 80 per cent and carbon dioxide 15 per cent. The presence of this latter constituent in so large an amount is worthy of note.

Analyses of Natural Gas from Wells in the Peace River Field, November, 1924

—	Victory Oil Co., Well No. 1	Peace River Petroleums, Ltd., Well No. 1	Canadian Petroleums, Ltd., Well No. 1		Tar Island Oil and Gas Co., Well No. 1	Northern Pacific Oil Co., Well No. 1	Peace River Oil Co., Ltd., Well No. 2
			As sampled*	Air-free			
Sample No	51	53	54	54	56	57	55
Depth of gas sands	1,530	840 to 857	1,145	to 1,258	855 to 980	800	864
Specific gravity	0·686	0·590	0·758	....	0·750	0·572	0·712
Constituents, per cent—							
Methane (CH_4)	81·40	....	56·35	78·2	76·05	....	....
Ethane (C_2H_6)	2·66	....	10·65	14·8	0·99	....	....
Carbon dioxide (CO_2)	15·47	....	1·59	2·2	18·80	....	....
Oxygen (O_2)	0·27	....	5·86	....	Nil	....	....
Nitrogen (N_2)	0·20	....	25·55	4·8	4·16	....	....
Helium content	0·012	0·007	0·004	0·005	0·006	0·006	0·015
Gasoline content	Nil	....	....	Nil	Nil	....	....
Hydrogen sulphide	Present in all the gases.						

* The sample was taken from a separator erected by the company to obtain gas for drilling No. 2 well. The pipes were badly corroded by the action of the salt water and it is probable that air was drawn in and mixed with the gas. Density measurements made at the well, gave high results and the gas burned with a non-luminous flame as though it contained air.

[1] McConnell, R. G.: Geol. Surv., Canada, Ann. Rept., Vol. V, pt. D (1890–91).
McLearn, F. H.: "The Cretaceous of Peace and Athabaska Valleys," Geol. Surv., Canada, Mem. 116, pt. III (1919). *Also* Geol. Surv., Canada, Sum. Rept. 1918, pt. C, pp. 1–7.

Helium Content and Quantity of Gas

In six wells tested the gas averaged about 0·07 cubic feet of helium per M. cubic feet of gas, or about 0·007 per cent. No large quantity of gas is available at present.

The Athabaska River Field[1]

Natural gas has been found at widely distant points along the Athabaska river, at Athabaska Landing, at Pelican rapids, at House river, and in small showings in several wells drilled north of McMurray. Several gas springs at Little Buffalo river and other points near Grand rapids have been reported. No drilling has been done at points inland from the river and the extent of the area in which gas might be found is not definitely known. The wells drilled in this field have been free from the water trouble that is such a handicap in the Peace River field.

Composition of Gas and Available Supply

Samples of gas were collected for analyses from each well from which there was a flow. Tests for the gasoline content using the charcoal absorption method were also made in every case with negative results.

The results of the analyses are as follows:—

—	Athabaska Landing, Government well	Pelican Rapids			House River
		Upper wells		Lower well	
		No. 1	No. 2	No. 1	
Sample No.	58	62	63	....	60
Depth of gas sands	334, 780	850	....	820	600
Specific gravity	0·569	0·579	0·588	0·569	0·618
Constituents, per cent—					
Methane (CH_4)	94·80	97·80	....	83·5*a*	70·4*b*
Ethane (C_2H_6)	2·01	1·27	....	....	15·1
Carbon dioxide (CO_2)	0·34	0·79	....	1·0	2·6
Oxygen (O_2)	0·51	0·14	....	2·9	Nil
Nitrogen (N_2)	2·34	....	....	12·6	11·9
Helium content	0·022	0·016	0·019	0·012	0·006
Gasoline content	....	Nil	....	Nil	Nil

a Analysis by E. Stansfield. Sample taken by F. H. McLearn, July 1916.
b Calculated air-free.

Gas in commercial quantity can now be obtained from only one well at the Lower Pelican location and one at the Upper Pelican. These two wells have a rock pressure of about 300 pounds per square inch and an open flow of about 3 or 4 million cubic feet each per day. If an increased supply were required new wells could be readily drilled.

The average helium content is about 0·2 cubic feet per M cubic feet of gas; therefore the field is of no value as a source of helium.

[1] Mines Branch, Dept. of Mines, Canada, Natural Gas and Petroleum in Northern Alberta; Invest. Min. Res. and Mg. Ind., 1924, p. 112.
Geol. Surv., Canada, Ann. Rept., Vol. V, pt. D (1890–91).

Wainwright Field[1]

This field lies about 100 miles southeast of Edmonton, between Irma and Wainwright and near the main line of the Canadian National railway. It has attracted considerable attention during the last three or four years and although no large oil-producing wells have been found, drilling is still in progress. So far about 15 wells have been drilled and several of them have given large flows of natural gas or small yields of oil. No estimates have been made of the possible gas reserves. The geology of the area has been carefully studied by G. S. Hume of the Geological Survey, and several reports have been published.[1]

At present there is no large demand for the gas as Edmonton is already supplied from the Viking field. A pipe-line system has been planned to supply the town of Wainwright.

The gas sands are usually struck at 1,700 to 2,000 feet. The open flows and well pressures of the different wells vary greatly.

Character of Gas and Helium Content

The gas is a dry gas containing about 88 per cent methane and 4 per cent ethane. The average helium content is only about 1·0 cubic feet per thousand and on that account the field does not warrant consideration for the possibilities of helium recovery.

The following analyses have been made:—

Wells	Location			Depth	Constituents					Sp. Gr.	Helium %
	Sec.	Tp.	R.	Feet	CH_4	C_2H_6	CO_2	O_2	N_2		
British Petroleums No. 1....	36	45	7	2,010	87·3	4·4	0·3	1·0	7·0	0·62	....
British Petroleums No. 3....	29	45	6	2,140	86·8	10·8	0·1	0·1	2·2	0·611	0·082
British Petroleums No. 4....	30	45	6	2,036	92·2	2·0	0·3	0·2	4·4	0·584	0·109
Maple Leaf Oil Co. No. 1......	24	45	8	1,720	90·0	7·2	......	0·1	2·7	0·599	0·096
Maple Leaf Oil Co. No. 1......	24	45	8	352	94·1	4·0	0·2	......	1·7	0·579	0·076
Imperial Oil Co., Fabyan No. 1..	18	45	7	2,205	88·6	2·6	0·3	0·8	7·7	0·610	0·060
British Petroleums No. 2....	30	45	6	2,019	......	....	......	......	......	0·577	0·110
Imperial Grattan.	4	45	8	......	......	....	......	......	......	0·600	0·091

The Viking Field

The Viking field is situated about 80 miles southeast of Edmonton and is close to the main line of the Canadian National railway. The field is probably a local fold developed near the western edge of the terrace structure

[1] Hume, G. S.: "Notes on Developments in the Wainwright Field, Alberta, Geol. Surv., Canada, Sum. Rept., pt. B, 1925.
Elworthy, R. T.· "Natural Gas in Alberta," Mines Branch, Dept. of Mines, Canada, Invest. Min. Res. and Mg. Ind., 1923, p. 18.
Ross, C. C.· "Petroleum and Natural Gas Development in Alberta," Can. Inst. Min. Met., Bull. 168, p. 482 (April, 1926).

described by G. S. Hume. The first wells were drilled in 1914 although the gas was not used until 1923. There are two gas horizons, one at about 2,150 feet and a second at 2,350 feet. At present there are 12 wells drilled with a rock pressure of about 700 pounds per square inch and an average flow of about 5,000 M. cubic feet per day.

A pipe-line, 10 inches in diameter and about 80 miles in length was laid to Edmonton in the summer of 1923, also supplying a few small towns along the line. The consumption reported in 1924 was 954,221 M. cubic feet.

Character of Gas and Helium Content

The gas is a dry gas consisting of 92·5 methane and 3·5 per cent ethane. The helium content of both of the individual wells tested and of the pipe-line gas is about 1·2 cubic feet per thousand cubic feet (0·12 per cent). The gas from this field, therefore, does not warrant consideration for extraction purposes.

The Many Island Lake Field

Location and Extent

The field is 40 miles east of Medicine Hat and is probably an extension of the Medicine Hat field. Six wells have been drilled in township 14, range 11, but only one of these has struck gas in large quantity. The gas sands are found at a depth of 1,300 to 1,500 feet. Little geological work has been done in this area and the extent of the field is not yet defined. The gas so far found has been in too small a quantity to warrant much consideration of its use. The establishment of a carbon black plant has been proposed. No pipe-lines have been put down.

Character of Gas and Helium Content

The gas closely resembles that from the Medicine Hat field and is composed of about 95 per cent methane and 5 per cent nitrogen. The specific gravity is 0·59. The helium content (two wells tested) is about 0·7 cubic feet per M. (0·07 per cent).

No gas is available at present and the field is of no interest for helium production unless richer gases are found.

Medicine Hat Field[1]

The proved gas area in the vicinity of Medicine Hat covers about 40 or 50 square miles and it is believed that future drilling may open up wells to the northwest of this area.

There are two gas horizons in this field, one at 600 to 800 feet and the other, the larger reservoir, at 1,000 to 1,200 feet depth, the gas coming from the Milk River sandstone. At present about 30 wells have been drilled in the area, and 2 or 3 are being drilled.

[1] Ross, C. C.: Petroleum and Natural Gas Development in Alberta, Can. Inst. Min. Met. Bull. No. 168, p. 484 (April, 1926).

Use

Gas from the wells is used for domestic and industrial consumption in Medicine Hat and Redcliff. The wells are scattered over the outskirts of the city and there are a number of small diameter pipe-lines, there being no large main pipe-line conveying the greater part of the gas to the city as there is for Edmonton and Calgary. The total consumption in 1924 was 1,966,567 M cubic feet.

Character

The gas is a dry gas of specific gravity 0·56, and the chief constituent is methane (95 to 98 per cent). The helium content is about 1·2 cubic feet per M (0·12 per cent).

Analyses: Medicine Hat and Many Island Lake Fields

Well	Location			Depth	Constituents					Sp. Gr.	Helium %
	Sec.	Tp.	R.	Feet	CH_4	C_2H_6	CO_2	O_2	N_2		
Medicine Hat city gas	......	12–13	5–6	800 1,000	97·8	0·3	0·4	......	1·5	0·565	0·116
Canadian American Oil Co. Well No. 1	19	14	1	1,200	96·3	0·5	0·5	0·3	2·4	0·578	0·067
Medicine Hat Development Co. No. 1	19	14	1	1,350	95·6	Nil	0·2	0·1	4·1	0·574	....
Community Oils No. 1	19	14	1	2,471	95·3	Nil	0·9	Nil	3·8	0·567	0·060

Sweet Grass Field

The Sweet Grass field in southern Alberta covers a strip of country adjacent to the International Boundary in the neighbourhood of the town of Coutts. The development of the Kevin-Sunburst field in Montana in 1920-1921 gave rise to much activity on the Canadian side of the border and a number of wells were drilled in 1922-23. No oil in commercial quantity was found and only one well, the Rogers-Imperial (Canadian Oil and Refining Co.) has given much gas. It is reported to have a flow of 50,000 M cubic feet per day, and was struck in May, 1924, at a depth of 2,530 feet. The rock pressure is 1,180 pounds per square inch. The gas comes from sandstone of Kootenay age. There is the possibility of a large gas field in this area.

No use has been made of the gas and as yet there is no domestic demand. No pipe-lines have been laid.

Character of Gas

The gas is a dry gas of specific gravity 0·57 and is composed of 94 per cent methane, 2 per cent ethane, and 3 per cent nitrogen. The helium content is 0·9 cubic feet per M (0·09 per cent).

Quantity of Gas Available

At present the Rogers-Imperial is the only well that gives much gas. The helium content is too low, however, to make the gas of value as a source of helium.

Foremost Field

This area is in southern Alberta between the Bow Island and the Sweet Grass fields, near the town of Foremost on the Canadian Pacific railway southeast from Lethbridge. A well located in Etzikom coulee was drilled in 1915 by the United Oil Wells Limited, in which large volumes of gas were struck but no oil. Water was allowed to drown out the gas and nothing further was done. In 1923 the Canadian Western Natural Gas, Light, Heat and Power Company drilled two wells to the northwest and southeast of this first well to test out the field. Both wells gave large flows of gas and little water was encountered. Seven other wells have since been completed and all have yielded large supplies. There are three productive sands in the Colorado shale and it is believed that there is a large gas reservoir in this area.

Particulars of Wells

These were drilled by Canadian Western Natural Gas, Light, Heat and Power Company.

Well No.	Depth sand	Rock pressure	Open flow M cu. ft. per day	Helium content cu. ft. per M	Date tested
1	2,181 to 2,191	660	17,000	2·0	Oct. 1923
2	2,190	660	7,500	1·9	April 1925
3	2,019	600	2,000	2·1	April 1925
4	2,100	700	23,000	1·8	April 1925
5	2,207	600	11,000	Not tested	
6	2,200	585	1,330	"	

The gas is a dry gas of specific gravity 0·610. The main constituents are 94 per cent methane, 1 per cent ethane and 5 per cent nitrogen. The average helium content is 2 cubic feet per thousand cubic feet of gas.

Available Supply

A pipe-line 40 miles long and 10 inches in diameter was laid in 1923, joining up with the Bow Island pipe-line to Calgary at Burdette. Until the recently obtained large supply of gas from the Turner Valley field was made available for Calgary this field was of great value.

The actual quantity of gas passing through the Foremost pipe-line, reported by the Canadian Western Natural Gas, Light, Heat and Power

Company for October, November, and December, 1924, was 581,515 M cubic feet and on this basis averaged 200,000 M cubic feet a month in the early parts of 1925, or a total production of 1,200,000 M cubic feet for six months.

Assuming that helium could be extracted from a natural gas containing as little as 2 cubic feet per thousand and allowing 80 per cent recovery, the quantity of helium that could be obtained from the six months' total production is approximately 2,000,000 cubic feet.

On the basis of taking 25 per cent of the total open flow per day from the wells the possible recovery of helium would greatly exceed this figure. However except in cases of extreme need it would not be economic to process this amount of gas for helium recovery unless there was an economic demand for the treated natural gas. Under present conditions in Alberta that possibility cannot be considered and the maximum production of helium stands at the lower figure of 2,000,000 cubic feet. Moreover, this quantity is based on the assumption that a natural gas with such a low helium content can be economically treated for its recovery; a fact which could only be proved by large-scale experiments.

Bow Island Field

The Bow Island field situated in the centre of southern Alberta has been drawn upon since 1908 and is therefore one of the oldest gas fields in western Canada. It covers an area of about 20 square miles and the eighteen or twenty wells that have been drilled lie along and near the south bank of the Saskatchewan river. The original rock pressures in this field were about 700 to 800 pounds per square inch and open flows of seven and eight million cubic feet a day were common. The principal supply of gas comes from sands in the Benton formation at about 1,900 feet, although a small amount is obtained at 800 to 1,000 feet in the Belly River shales.

During the last few years the gas supply has greatly diminished and many of the wells have suffered from water. During the summers of 1923 and 1924 a number of the wells were cleaned out and afterwards closed in, thus allowing a supply to build up for use during the winter months. A report made by engineers appointed by the Public Utilities Commission of Alberta showed that this treatment greatly benefitted the field. It was found that the field would give an open flow of 17,000 M cubic feet per day and that 12,000 M cubic feet at 60 pounds pressure might be fed into the line for short periods. In three years, from 1917 to 1920, the rock pressure dropped from 615 pounds per square inch to 204 pounds.

Use

The gas delivered by collecting pipe-lines from the various wells, after passing through a central measuring station, enters the 16-inch main pipe-line running from Burdette to Calgary, a distance of 160 miles.

Helium Content

Gas from a number of the Bow Island wells was analysed during the years 1916 to 1918 by Prof. McLennan and Mr. J. Patterson. Since that time a number of the wells have been abandoned. In March 1925 a further

set of samples were collected and analysed. The results of both these surveys are assembled in the following table:—

Well No.	Rock pressure 1923	Open flow Sept. 1923 M cu. ft.	Helium content cu. ft. per M	Date tested	
4	201	1,901	2·9	April 1916	J. C. McLennan
4	201	......	2·92	Mar. 1925	R. T. Elworthy
3	198	1,566	2·98	Mar. 1925	R. T. Elworthy
3, 11, 14	......	......	2·9	April 1916	J. C. McLennan
9	207	1,802	2·98	Mar. 1925	R. T. Elworthy
9, 10 and southern Alberta	......	......	3·0	Dec. 1918	J. Patterson
16	......	......	3·4	April 1916	J. C. McLennan
19	178	623	3·33	Mar. 1925	R. T. Elworthy
22	171	538	3·3	Dec. 1918	J. Patterson
Gas from pipe-line at Calgary (a)	......	......	3·3	April 1916	J. C. McLennan
Gas from pipe-line at Calgary (b)	......	......	0·16	Oct. 1924	R. T. Elworthy
Gas from pipe-line at Lethbridge (c)	......	......	2·84	Mar. 1926	R. T. Elworthy

(a) Gas then obtained only from Bow Island field.

(b) This gas is mainly from the Turner Valley, with a small amount from the Bow Island and Foremost fields.

(c) This gas is a mixture of gas from the Bow Island and Foremost fields.

The average helium content of gas from the Bow Island wells would, therefore, run about 3 cubic feet per thousand cubic feet of gas.

Gas Analyses

The following analyses show the character of the gas from this field. Samples from Foremost and Chin Coulee (Barnwell) are included.

Well[1]	Location			Depth	Constituents					Sp. Gr.	Helium %
	Sec.	Tp.	R.	Feet	CH_4	C_2H_6	CO_2	O_2	N_2		
Bow Island—											
Well No. 3	9	11	11	1,887	89·4	2·8	0·4	......	7·4	0·602	0·298
" 4	17	11	11	1,879	91·2	1·0	......	0·2	7·6	0·591	0·291
" 9	24	11	12	1,911	88·6	2·3	......	0·4	8·7	0·604	0·337
" 19	25	10	12	2,146	89·1	1·6	......	0·2	9·1	0·609	0·333
Chin Coulee—											
Well No. 1	31	9	17	2,166	84·8	1·6	0·2	1·1	12·3	0·621	0·386
" 25	31	9	17	......	87·9	3·7	......	......	8·4	......	0·36
Foremost—											
Well No. 1	1	6	11	2,191	90·9	0·6	......	......	8·5	0·592	0·225
" 4	12	6	11	2,100	97·0	0·5	0·3	......	2·2	0·644	0·213
Lethbridge pipe-line	......	......	......	......	83·8	2·8	......	0·1	13·3	0·624	0·28
Calgary city main, 1914	......	......	......	......	91·6	......	......	0·2	8·2	0·59	0·30

[1] All these wells are operated by the Canadian Western Natural Gas, Light, Heat and Power Co.

Quantity of Gas Available

The following production figures have been supplied by the Canadian Western Natural Gas, Light, Heat and Power Company for the year 1924.

	M cu. ft.		M cu. ft.
January	133,514	July	18,422
February	51,502	August	28,877
March	45,254	September	31,854
April	42,093	October	66,234
May	20,840	November	19,111
June	51,441	December	17,282
		Total	526,424

If a recovery of 80 per cent of the total helium be assumed, the yearly production would amount to approximately 1,250,000 cubic feet.

However, the wells in this field are nearly exhausted and it is probable that the production will decline year by year, particularly as no more drilling is being carried on.

The Chin Coulee or Barnwell Field

The Chin Coulee field is about 50 miles to the west of the Bow Island field, and on the main pipe-line to Calgary. It is located on a more or less pronounced structure occurring on what is known as the west limb of the Sweet Grass arch. Although eight wells have been drilled, gas has been obtained in only four of them and to-day only two wells are in use. The field is not regarded as exhausted but no further drilling is expected to be done at present. It is operated by the Canadian Western Natural Gas, Light, Heat and Power Company. The gas from wells No. 1 and No. 7 is put into the main Bow Island-Calgary pipe-line during the winter months.

Helium Content

Gas in this field was examined in 1918 by Mr. John Patterson and found to be the richest in helium of any in Alberta. Samples were also taken in March 1925 and tested. The results were as follows:—

Well No.	Depth	Rock pressure	Open flow	Helium content	Date tested
	feet	lb. per sq. in.	M. cu. ft.	cu. ft. per M	
25	....	....	....	3·6	1918 J. P.
1	2,200	215	800	3·8	1925 R. T. E.
7	2,155	300	700	4·0	1925 R.T. E.

Amount of Gas Available

In 1924 only 27,424 M cubic feet of gas was taken and that only in the winter months, according to reports furnished by the Canadian Western Natural Gas, Light, Heat and Power Company. The quantity of helium in this gas, assuming an average content of 3·8 cubic feet per thousand, would be approximately 104,000 cubic feet. This amount is too small to make the field of any value as a source of helium.

Turner Valley Field[1]

This field is situated in the foothills of the Rocky mountains to the southwest of and about 40 miles from Calgary. It is to-day the chief oil field in Canada. Wells were first drilled in 1914 and great interest in its possibilities was aroused. These were not realized, however, and little attention was paid to the field until the Imperial Oil Company in drilling the Royalite No. 4 well in September, 1924, after several years of persistent effort, opened up the biggest oil well so far found in Canada. At 3,740 feet a flow of wet gas amounting to over 20,000,000 cubic feet per day was struck and due to the tremendous pressure the well went out of control and eventually caught fire. The difficulties were soon overcome and for more than a year the well has yielded 500 barrels a day of light oil. Several new wells are now being drilled and a number of the old wells are being deepened and it is anticipated that the field will become of great importance. Even in 1924 the production of oil from this field, almost entirely from Royalite No. 4, was greater than the total Canadian production from all other fields.

For a number of years previously, four or five wells were producing some 4,000,000 cubic feet per day of gas which was treated to remove its gasoline content and then piped into the Bow Island-Calgary pipe-line at Okotoks, 15 miles away.

These older wells drilled to about 3,000 feet, obtained their gas from the Dakota and Kootenay formations. The newer deep reservoirs are in dolomite limestones. On account of the folded and disturbed nature of the formations drilling in this area is difficult and expensive.

Character of Gas and Helium Content

The gas is a wet gas yielding two or three pints of gasoline per thousand cubic feet. The chief constituents are, methane 70 per cent, ethane 28 per cent, and nitrogen 1 per cent. The helium content is unfortunately low being only about 0·1 cubic feet per thousand. Gas from the deep horizon in Royalite No. 4 contains only 0·009 per cent of helium.

The following analyses have been made:—

Wells	Location			Depth	Constituents					Sp. Gr.	Helium. %
	Sec.	Tp.	R.	Feet	CH_4	C_2H_6	CO_2	O_2	N_2		
Southern Alberta, Well No. 2	18	20	2	3,575	52·0	45·1	1·4	0·8	0·7	0·86	....
Illinois, Alberta, Well No. 1	12	20	2	3,038	67·4	30·0	1·0	0·2	1·4	0·72	....
McLeod Oil Co., Well No. 1	1	20	3	2,397	32·1	66·4	1·1	0·5	....	0·891	....
Royalite Oil Co., Well No. 1	20	20	2	3,910	71·8	25·9	2·1	0·3	0·9	0·70	0·03
Royalite Oil Co., Well No. 3	20	20	2	2,830	67·2	30·3	1·7	....	0·8	0·71	0·061
Royalite Oil Co., Well No. 4	7	20	2	....	69·6	26·7	1·8	0·5	1·4	0·712	0·009

[1] Ross, C. C.: "Petroleum and Natural Gas Development in Alberta," Can. Inst. Min. and Met., Bull. 168, p. 468 (1926).
Also Slipper, S. E.: "Sheep River Gas and Oil Field," Geol. Surv., Canada, Mem. 122 (1921).

All these gases carry gasoline which is recovered by the oil-absorption process by the Royalite Oil Company and by the Jennings Refining Company. Hydrogen sulphide is an impurity, particularly in the gas from the deeper horizon and a Koppers purifying plant has been installed to treat the gas before it is piped to Calgary. The pipe-line is 10 inches in diameter, and was laid in 1925. Although large quantities of gas, up to 10 or 12 million cubic feet per day, will be available, particularly in the winter months, the helium content is too small to make its recovery practicable.

The economic disposal of the large volumes of natural gas available in the field, particularly if, as is probable, similarly large flows to that from Royalite No. 4, are opened up in some of the new wells which are being drilled, is a problem of great importance from the viewpoint of conservation.

ONTARIO

The gas fields of Ontario are all found in the southern part of the province. The earliest gas wells were drilled in Essex and Welland counties in the year 1889 and from that date the production increased rapidly until the peak was reached in 1917 when over nineteen million M cubic feet was consumed. In later years the production has diminished and the declining supply has called for stringent measures of conservation on the part of the Provincial Government.

In 1924 the total amount consumed was 7,422,880 M cubic feet, valued at $4,214,798.

The chief gas fields at the present time are in Lambton, Kent, Norfolk, Haldimand, and Welland counties. The production and distribution of gas is controlled mainly by three companies; the Union Natural Gas Company, in Lambton, Kent, and Essex counties; the Dominion Gas Company, in Kent, Norfolk, and Haldimand counties; and the Provincial Natural Gas Company, in Welland and Haldimand counties.

The fields, together with the main systems of pipe-lines for distribution of the gas, are shown on the accompanying map.

Lambton County

There are three gas fields in Lambton county, the Sarnia field, the Petrolia Oil Springs field and the Dawn field. The supply from any one of these is not very great.

SARNIA FIELD

Sixteen small wells were drilled in the vicinity of Sarnia in 1921-22. The productive horizon is in the Onondaga limestone at a depth of about 450 to 500 feet. The rock pressure is about 100 pounds per square inch and the open flow of the best of the wells is about 100 M cubic feet per day. The available gas supply is not thought to be very large and no use is made of the gas and no pipe-lines are laid. The town of Sarnia is supplied with gas from the Dawn field and the Tilbury field.

Helium Content and Character of Gas

The helium content (six analyses) is about 0·5 cubic feet per thousand (0·05 per cent). The gas is mainly methane, 90 per cent, with 1 per cent ethane and 3 per cent nitrogen.

The field is of no importance as a source of helium.

OIL SPRINGS FIELD

This is the chief producing oil field in Ontario but the peak of production is passed and the supply is fast declining. Comparatively few of the many wells in this area yield gas at the present time though when first drilled, ten or fifteen years ago, some heavy flows were encountered. Most of the gas wells are about 2,000 feet deep, drawing gas from the Salina or Guelph formations, whereas the oil is found at 400 feet in the Onondaga formation.

Helium Content

The helium content of gas from these wells is about 1·4 to 1·9 cubic feet per thousand cubic feet of gas (0·14 to 0·19 per cent)(six wells tested).

The gas is of no importance for the production of helium, on account of the declining supply and the low helium content.

DAWN FIELD

This field is a relatively new field, having been opened up in 1922 by the Union Natural Gas Company. It lies about 10 miles south of Petrolia. There are five producing wells about 1,600 to 1,900 feet deep. The gas is believed to come from sands in the Niagara formation. The underground conditions are not fully understood, as the gas sands are found at different depths in almost each well. The rock pressure in most of the wells is high but falls off very rapidly.

The gas from the wells passes into a 6-inch diameter main which runs north to Petrolia and thence west to the Sarnia line. The approximate quantity passing through the line is about 56,000 M cubic feet annually, though this quantity is delivered only during the winter months, the wells being shut in in the summer. The average daily production is about 800 M cubic feet per day.

Helium Content

Gas from all the wells was tested in June, 1925. The following results were obtained:—

Well No.	Location		Depth gas sand	Helium content
	Lot	Con.		
			feet	cu. ft. per M
1	24	7	1,580	1·39
3	24	5	1,615, 1,750	1·39
4	23	4	1,614, 1,639	1·83
6	24	5	1,905	2·14
7	25	8	1,842	2·52

It is probable that the helium content of the pipe-line when all the wells are on the line would be about 2·0 cubic feet per M.

The quantity of gas available for treatment together with the comparatively low helium content does not warrant consideration of helium extraction.

Kent County

THE TILBURY FIELD

This field which covers a large part of Tilbury township and also parts of Romney and Raleigh townships has produced gas since 1907. It is still one of the main producing fields in Ontario. It has been examined by many experts and its reserves and probable rate of decline have been forecast.

Most of the wells are from 1,100 to 1,600 feet in depth. The gas is found in the Guelph or Salina formations.

Character of Gas

The gas is a dry gas with a specific gravity of about 0·630. It contains principally: methane, 84 per cent; ethane, 11 per cent; and nitrogen, 4 per cent. Hydrogen sulphide is an objectionable impurity and the Union Natural Gas Company has lately installed a Koppers purifying system. The process reduces the hydrogen sulphide content from about 385 grains per 100 cubic feet, to an average of about 10 grains per 100 cubic feet, and seems most successful in operation.

Helium Content

The average helium content is low, about 0·13 per cent. Nine wells and two pipe-line samples have been tested.

Use

The Union Natural Gas Company and the Southern Ontario Gas Company both take gas from this field. The former company's main metering station is at Port Alma and from this point two pipe-lines (8 inches in diameter) run west to supply Windsor and other towns and villages in the extreme west of the peninsula. Another 10-inch diameter line runs north to Sarnia, with branches to Wallaceburg, and many smaller towns, and another 8-inch diameter main conveys gas to the city of Chatham. One line runs east along the lake shore separating a network of smaller lines which supply Blenheim, Charing Cross, Erie Beach, Ridgetown, and a number of villages on the way. The Southern Ontario Gas Company runs a pipe-line east supplying gas to Ingersoll, Woodstock, Brantford, Galt, Paris, and certain outlying districts of Hamilton.

There are about 250 producing wells in this field with an annual production of about 5,500,000 M cubic feet.

The helium content is too small to warrant the separation of helium from gas in this field.

THE DOVER FIELD

The Dover field on the shores of lake St. Clair in Dover township, is a small field of little importance from the point of view of helium extraction. The helium content of the gas is 0·13 per cent. The annual production is about 300,000 M cubic feet, from nine wells. The field is controlled by the Union Natural Gas Company.

HOWARD TOWNSHIP

In Howard township, near Ridgetown, there are a number of shallow gas wells, which seem extraordinarily productive and lasting. These have now been taken over by the Union Natural Gas Company and joined up to their system. In view of the fact that many of the richest helium-bearing gases come from shallow wells, gas from some of these wells was tested with particular interest.

However, the helium content was only 0·03 per cent. The field is of no value, therefore, for helium production.

Elgin County

BAYHAM TOWNSHIP

There is a small gas field in the south of Bayham township in which two companies, the Dominion Gas Company and the Medina Gas Company have wells, the former about 30 and the latter 25. One pipe-line, 6 inches in diameter, owned by the Dominion Gas Company, runs north from Port Burwell on the lake shore, through Straffordville to Tilsonburg. The Medina Gas Company supply the town of Aylmer.

The total production in 1922 was about 160,000 M cubic feet.

Helium Content

Gas from three wells at different points in the field and from the main pipe-line of the Medina Gas Company was examined in 1925.

The following results were obtained:—

Well No.	Location		Rock pressure	Open flow	Helium content
	Lot	Con.			
			lb./sq. in.	M cu. ft.	cu. ft. per M
Medina No. 5	10	3	101	11	2·35
" No. 2	14	2	115	6	2·19
Richmond No. 1	1	5	230	16	2·56
Main pipe-line—Vienna	...	...	...	...	2·38

The helium content is not high enough nor the annual production sufficient to warrant consideration of helium extraction.

Norfolk County

The preliminary survey of the helium content of gas from three fields in Norfolk county in 1924 showed that some of the natural gas from this area was, with the exception of gas from the Caledon field, Peel county, the richest in helium so far found in Canada. More extended investigation in 1925 has confirmed the earlier results.

The chief areas in which wells have been drilled are in the vicinity of the towns of Port Dover and Port Ryerse, in the southwest part of Woodhouse township, and the towns of Lynedoch and Delhi, in the southwest

corner of Windham township and southeast corner of Middleton township. A smaller field lies near Port Rowan and Port Royal in South Walsingham township. These fields have been drawn upon for some time.

Two new fields have lately been opened up, one area on the borders of Townsend and Woodhouse townships where two good wells have been lately drilled, and the other in the north corner of Middleton township where five productive wells drilled during the last two years have proved the existence of a good gas reservoir.

Wells in all these fields have now been examined and samples taken from some of the main pipe-lines.

All these fields are controlled and operated by the Dominion Natural Gas Company.

PORT ROYAL FIELD

In the neighbourhood of Port Royal and Port Rowan there are fourteen small producing wells. A short pipe-line joins up these wells and supplies both villages. The quantity of gas consumed in 1923 was about 28,000 M cubic feet. Although the helium content is 3·8 cubic feet per thousand the separation of the 100,000 cubic feet of helium recoverable would hardly warrant the treatment of this gas.

DELHI—LYNEDOCH FIELD

About thirty-five small wells located in the corners of Middleton, Windham, and North Walsingham townships produce about 120,000 M cubic feet of gas annually, a quarter of which is consumed in the towns of Delhi and Lynedoch, and the remainder piped to the town of Simcoe. The wells are usually about 1,100 to 1,500 feet deep and gas is found in the Clinton or Red Medina formations. The rock pressure in new wells is about 500 pounds, but it soon falls off. The average rock pressure for the field is about 350 pounds per square inch.

Helium Content

Gas from the following wells was examined:—

Sample No.	Well	Township	Lot	Con.	Rock pressure	Depth gas sand	Date drilled	Date tested	Helium content
					lb./sq. in.	feet			cu. ft. per M
23	Charlton No. 1..........	Windham.....	24	13	300	1,113	....	1924	3·3
~~118~~	T. J. Brown	N. Walsingham.	21	14	540	1,175	1921	1925	3·7
22	" "	" "	21	14	540	1,175	1921	1924	3·8
126	Anson Quance	Middleton....	43	2	550	1,246	1919	1925	3·9
124	Gas from pipe-line from Delhi-Lynedoch field at Simcoe.								3·8

This gas as piped into Simcoe is a possible source of helium. This possibility is discussed later.

MIDDLETON TOWNSHIP FIELD

A productive field is being developed in the northwest corner of Middleton township. Several good wells have been drilled in the last two years, and a 3-inch pipe-line has been laid to augment the Tilsonburg supply.

It is probable in the near future that a larger diameter line will be put down to link up this field with the Southern Ontario main pipe-line at Ingersoll.

The wells are usually about 1,270 to 1,350 feet deep and gas is found in the Clinton formation at about 1,250 feet. The rock pressure is about 650 pounds and the open flows vary from 200 to 800 M cubic feet per day.

Helium Content

Gas from two wells was tested in 1925.

Sample No.	Well	Lot	Con.	Depth gas sand	Date drilled	Helium
				feet		cu.ft.perM
116	Fisher No. 1	16	2	1,253	1924	2·7
117	Alex. Teller	15	2	1,246	1924	2·9

No data are yet available on the annual production from this field. The helium content is not as high as in the fields in Norfolk county and at present the possibilities of extracting helium do not warrant consideration.

WOODHOUSE TOWNSHIP

In Woodhouse township, in the vicinity of Port Dover and Port Ryerse there are between sixty and seventy wells supplying gas to these villages and to the town of Simcoe. The wells are usually about 1,000 to 1,200 feet deep, and the productive gas horizon is in the Clinton and Red or White Medina formations. The rock pressures, although high when the wells are first opened up, soon drop. The present average rock pressure in the field is about 250 pounds per square inch.

Helium Content

The field covers an area about 6 miles long and 4 miles wide. The following results were obtained from the examination of samples from wells along each side and near the centre of this rectangle.

Sample No.	Well	Lot	Con.	Depth	Formation	Date drilled	Date tested	Helium
				feet				cu.ft.perM
	Port Dover....	Shore		1,043	White Medina	1906	June, 1924	3·4
113	Wedlake.......	Port	Dover	1,018	Clinton.......	1908	July, 1925	3·2
123	P. Boulter.....	7	2	1,027 1,048	Clinton and Red Medina	1910	July, 1925	3·9
122	J. Livesay.....	7	3	1,039	Red Medina..	1906	July, 1925	3·5
121	W. Holloway...	6	4	990, 1,032	Clinton and Red Medina	1923	July, 1925	2·6
114	Dixon No. 1....	7	1	1,021	Red Medina..	1915	July, 1925	4·2
	Boyd No. 1....	Port	Ryerse	1,100	Red Medina..	....	June, 1924	4·3
	L. Oakes*......	24	3	1,129	Clinton.......	1910	July, 1925	3·8
120	H. Williams....	4	B.F.	1,058	Red Medina..	1923	July, 1925	4·5

*Charlotteville tp.

No explanation can yet be advanced for the variation in helium content. The wells are all drilled to about the same depth and the gases are believed to come from the same formations. It is probable, however, that all the wells would give results of the same order.

TOWNSEND FIELD

Two new wells lately put down on the border of Townsend and Woodhouse townships, close to the provincial highway between Simcoe and Jarvis, have shown the existence of a good gas reservoir in that area. Samples taken from these two wells were tested with the following results:—

Well.	Township	Lot	Con.	Rock pressure	Open flow M	Depth feet	Helium, cu. ft. per M
Yomans	Townsend	16	14	400	105	....	5·2
W. Mitchell	Woodhouse	15	6	400	285	1,058 to 1,155	4·2

These wells are close to the main $5\frac{5}{8}$-inch diameter pipe-line running from Simcoe to Jarvis and the gas can, therefore, be sent in either direction as required.

Character of Gas in Norfolk County

The gas from all the fields is of the same type and the constituents vary very little. It has a specific gravity of about 0·66 and is composed of about 88 per cent methane, 5 per cent ethane, and 7 per cent nitrogen. A little carbon dioxide is usually present (0·1 per cent). Detailed analyses are given on pages 49-50.

Possibilities for the Extraction of Helium

Simcoe would seem to be one of the most suitable locations in Ontario for a helium extraction plant. Pipe-lines come into the town from the Delhi-Lynedoch field and from the Woodhouse field. It is probable also that the helium-rich gas from the new Townsend field could be brought in. By a suitable arrangement all the raw gas could be by-passed to receive treatment and could then be pumped into the town's mains.

The following statistics of the flow of gas into and consumed in Simcoe from these two fields were supplied by the Dominion Gas Company:—

Date, 1924	Lynedoch field	Woodhouse field	
January	12,189	25,020	
February	11,326	24,735	
March	10,633	22,066	
April	10,775	20,114	
May	8,733	14,473	
June	5,907	10,711	
July	2,850	7,971	
August	3,307	7,848	
September	4,038	8,861	
October	5,627	11,423	
November	8,500	17,435	
December	9,857	23,391	
	93,742	194,048	= 287,790 M cubic feet.

Tests on Pipe-line Samples

	Helium cu. ft. per M
Simcoe. Line sample gas from Lynedoch, July, 1925	3·8
Simcoe. Line sample gas from Woodhouse, July, 1925	3·9
Simcoe. Gas sample, meter testing house, June, 1924	3·9

Assuming the efficiency of extraction to be 80 per cent, and also assuming that the helium percentage remains constant the year round, the possible yearly production of helium would be about 900,000 cubic feet.

Haldimand County

Gas fields are well distributed throughout this county though the most of the wells are small and there is no very big production. The first wells were drilled in 1905 by the Dominion Gas Company which still retains the predominant interest.

Until recent years Hamilton was supplied with gas from this county but the production became insufficient and artificial gas is now used in that city. Some gas is still piped to the outskirts of Hamilton, however, and St. Catharines obtains gas from the Canborough-Moulton field.

There is a network of pipe-lines over the county and gas passes in different directions at different times, depending on the demand, and the wells that are supplying the demand at the time.

The fields may be considered as follows:—

WALPOLE-RAINHAM TOWNSHIPS

In these townships the Dominion Gas Company has over 400 wells. The older wells are situated for the most part along or near the lake shore but recent drilling is being carried on more inland and some good wells are being opened up.

Most of the wells are drilled to the White Medina although gas is also obtained from the Clinton and Red Medina formations, at depths about 800 to 900 feet. The average rock pressure in 1911 was 250 pounds per square inch but has since dropped to 150 pounds.

Pipe-lines

One 6-inch pipe-line runs parallel to the lake shore, serving mainly as a collecting line. From this, other pipe-lines run north, one in Walpole township, supplies Hagersville and Jarvis; another, an 8-inch diameter pipe-line laid along the township line between Walpole and Rainham, conveys gas to Caledonia and Hamilton.

There are several other collecting lines feeding into these main supply lines. The gas is not metered in these lines and it is difficult to get reliable data on the quantity flowing.

Helium Content

A number of gas samples from wells and pipe-lines in this field were examined during 1924 and 1925. The results are as follows:—

Sample No.	Well	Lot	Con.	Date drilled	Depth gas sand feet	Formation	Helium cu. ft. per M.
142	E. A. Wright	16	8	1925	800	Red Medina	2·97
143	W. Edsel	15	Peacock pt.	1909	900	Red Medina	2·63
37	Laidlaw No. 2	18	7	....	790	Clinton	3·3
38	O. Shoup	14	3	....	1,005	White Medina	3·0
141	6-inch line on road between 5th and 6th Con. (12 wells)						2·84
147	Caledonia pipe-line at Selkirk regulating station (1925)						3·46
36	Caledonia pipe-line at Selkirk regulating station (1924)						3·10
154	Caledonia pipe-line at Caledonia						2·64
Rainham Township—							
145	J. J. Hoover	2	1	1909	815	Red Medina	2·79
29	W. Austin	24	1	....	850	Red Medina	2·6
146	G. Nagel, No. 1	13	2	1906	790	Red Medina	2·35
144	Pipe-line between 1st and 2nd concession						3·0

The analyses show that the helium content of the gas at the Selkirk regulating station was fairly constant in 1924 and 1925. The discrepancy between the value found at Selkirk of the helium content of gas flowing in the Selkirk-Caledonia pipe-line and of a sample from the same pipe-line at Caledonia is greater. The first sample was collected on July 6th and the second on July 8th. It is not known if there was gas of lower helium content fed into the line between these points.

Quantity of Gas Available

The consumption of gas in the town of Caledonia in 1924 was about 50,000 M cubic feet. Just how much has passed through Caledonia and goes into Hamilton is not known. However, there does not seem to be sufficient gas available to warrant consideration of a helium extraction plant in the Walpole-Rainham field.

CANBOROUGH AND MOULTON TOWNSHIPS

Wells were first drilled in these townships in 1905, and in 1912 sixty wells were producing in Canborough. To-day in the two townships there are about 260 producing wells.

Gas is usually struck at 500 to 600 feet, coming from sands in the Clinton and Red and White Medina formation. Open flows of 50,000 to 100,000 cubic feet are common. The initial rock pressures are about 300 pounds per square inch but soon drop when the wells are put into service. The average for the field is about 125 pounds per square inch. There are a number of low pressure wells in these areas, which have shown remarkable lasting power.

Helium Content of Gas

The following results have been obtained:—

Sample No.	Well	Lot	Con.	Date drilled	Depth of gas sand feet	Formation	Helium cu. ft. per M.
Moulton Township—							
129.....	W. Dolan..................	15	1	1905	....	....	2·65
130.....	C. Ackland................	15	2	1915	720	White Medina	3·03
136.....	A. Riley..................	24	N. Forks Rd.	1924	....	....	2·22
135.....	F. Dicont.................	10	3	1920	634, 770	White Medina and Clinton	2·36
32.....	W. Burch..................	15	N. Forks Rd.	....	676	White Medina	2·7
34.....	F. Speck..................	1	2	....	....	....	2·6
Canborough Township—							
132.....	T. Finch, No 1............	15	1	....	535	....	3·80
133.....	J. Potts, No 2............	11	1	1916	....	Clinton.......	2·65
29.....	C. VanKuren...............	5	3	....	650	White Medina	2·6
30.....	J. M. Allen...............	14	2	....	....	....	3.3
31.....	H. A. Lymburner.........	3	3	....	....	....	2·67
139.....	Gas from Bird road regulating station..						2·17
137.....	Gas from Canborough tp., Winger regulating station...................						2·71
131.....	Gas from Main line, Canboro Gas and Oil Co.............................						3·14
35.....	Gas from regulator house, Dunnville..						2·88

The average helium content is about 2·7 cubic feet per thousand cubic feet of gas.

Pipe-lines and Gas Available

There are a number of pipe-lines in this field, some of which join other lines at both ends. Consequently gas can and does flow in either direction depending on the demand. Estimates of possible quantities available for treatment are therefore difficult to make.

Four lines come into the town of Dunnville, one from the west, two from the north, and one from the east. The latter pipe-line, however, laid to Winger in Haldimand county, is the supply line to St. Catharines.

There are two places where gas could be treated in an extraction plant, one at the Dunnville meter and regulating station and the other at the Winger regulating and compressor station on the main St. Catharines line.

The following statistics of the flow of gas in 1924 at these two points was obtained from the Dominion Gas Company.

—	Gas entering Dunnville, all lines	Gas passing through Winger regulating station to St. Catharines
1924	M cu. ft.	M cu. ft.
January	16,546	27,742
February	18,319	25,850
March	17,020	23,534
April	12,964	25,649
May	9,598	23,877
June	6,653	19,198
July	3,783	11,278
August	3,607	11,191
September	5,024	13,826
October	6,924	16,729
November	10,890	23,547
December	15,811	27,966
	127,139	250,377

Assuming an average helium content of 2·7 cubic feet per thousand and an efficiency of recovery of 80 per cent, the quantities recoverable at these two points would be approximately 275,000 cubic feet and 540,000 cubic feet, respectively.

SENECA AND ONEIDA TOWNSHIPS: THE BLACKHEATH FIELD

Blackheath is the centre of a widely spread field with wells in Seneca and Oneida townships, Haldimand county; in Binbrook and Glanford townships, Wentworth county; and in Caistor township, Lincoln county. The total number of wells in this district is about three hundred. There has been a considerable amount of new drilling in Seneca township in the last two or three years. The wells are usually drilled to a depth of about 600 feet and gas is found in the Clinton and White Medina formations.

Helium Content of Gas

The following samples have been tested.

Sample No.	Township	Well	Lot	Con.	Date drilled	Depth	Helium content
						feet	cu.ft.perM
152	Oneida	P. Yuile No. 1	38	B.F.	1918	589	3·23
46	"	W. Martin No. 1	4	3	1923	685	3·4
47	"	J. Thomspon No. 1	64	R.R.	1921	543	2·9
149	"	Collecting line, feeding Caledonia-Hamilton line					3·08
8	Seneca	A. Emerson	3	Young's tract	1911,	533, 589	2·64
51	"	W. Robinson	15	2	1917	461	2·9
	"	15 wells in Con	5				3·2
134	Caistor	W. C. Lymburner			1918	422, 522	2·40
150	"	6-inch pipe-line going to Blackheath					2·58
151	Binbrook	J. Berry	31	9	1913	500	3·34
48	"	W. Beattie	9	26	1913	460	3·5
50	"	H. Johnston	4	3	1922	385, 440	2·1
157	Sample at Blackheath regulating station, line to Hamilton						3·09

Pipe-lines and Gas Available

The gas in Oneida township is fed into the main Caledonia-Hamilton 10-inch pipe-line. The wells in Seneca and Caistor townships feed pipe-lines which run to the Blackheath regulating station from which they are conveyed either along the $6\frac{5}{8}$-inch line running northwest along the township line or through the 8-inch line going north in Binbrook township. This line turns west at Elfrida and then north, finally joining up with the main Hamilton line at the regulating station outside Hamilton.

The only place where gas would be available for treatment would be at this regulating station. It was here that the original helium extraction experiments were carried out in 1918 under the direction of Prof. J. C. McLennan.

The amount of gas delivered at this point in 1924 from both lines was:—

	M cu. ft.		M cu. ft.
January	73,114	July	20,338
February	51,519	August	14,277
March	43,862	September	21,293
April	42,695	October	33,145
May	37,234	November	34,417
June	28,714	December	34,790
		Total	435,398

Assuming an average helium content of 2·8 cubic feet per thousand and an efficiency of extraction of 80 per cent, the quantity of helium recoverable per annum is approximately 980,000 cubic feet.

Welland County

The first successful gas wells were opened up in the southeastern part of Welland county in 1889 and until the last few years good supplies have been obtained. The field has now been fairly thoroughly tested and there appears little prospect of striking new gas reservoirs. Because of the declining supplies and the lower average helium content the area is not of much importance from the point of view of helium recovery.

The chief fields have been found in Wainfleet, Humberstone, and Bertie townships along the lake shore, and in Crowland and Willoughby townships.

From 1890 to 1896 natural gas was supplied to Buffalo from these fields. Now the position has been reversed by the recent importation of artificial gas from Buffalo to augment the supply for the town of Niagara Falls.

The Stirling Natural Gas Company

This company supplies Port Colborne and vicinity with gas, largely drawn from wells in Sherbrooke and Moulton townships in Haldimand county and in Wainfleet and Humberstone townships in Welland county. One pipe-line comes into Port Colborne from the west and two other small lines from the north. The quantity transmitted through the western line

in 1923 was 94,374 M. cubic feet. Port Colborne consumed in 1922 about 105,000 M. cubic feet. Assuming a helium content of 2·8 cubic feet per thousand, the recovery at 80 per cent efficiency would be approximately 235,000 cubic feet.

The Provincial Natural Gas Company

This company supplies Niagara Falls, Welland, Bridgeburg, Fort Erie, and other towns and villages in the east extremity of the peninsula.

The wells from which gas is obtained are in Crowland, Humberstone, Bertie, and Willoughby townships. Most of the wells have been drilled for many years and the supply and rock pressure are rapidly falling. The gas comes mainly from the Clinton formation which is encountered at 800 to 900 feet. There seems little prospect of further supplies being obtained.

The total production in 1922 from 94 wells was 463,675 M cubic feet. With the declining supply and comparatively low helium content it is not considered that the pipe-line system controlled by this company affords any opportunity for the recovery of helium.

Helium Content

The following results were obtained during the examination of these fields in 1924.

Sample No.	Township	Well	Lot	Con.	Depth	Formation	Helium
							cu.ft.perM
33	Wainfleet.....	W. Wills........	31	35	....	Medina...........	3·4
138	"	J. Snyder.......	30	5	....	"	2·61
39	Humberstone.	Menoah Minor..	31	3	....	"	2·5
40	"	Port Colborne Gas Co. line to Port Colborne................					3·1
41	Sherbrooke...	" " "					2·7
42	Bertie........	Point Abino well..........	....	....	902	White Medina.....	3·0
42 (a)	"	Well No. 471....	13	7	700–800	" "	2·3
44	Willoughby...	Well No. 61.....	4	2	2,940	Trenton..........	0·9
45	Crowland.....	Well No. 199....	4	3	700	Clinton..........	2·5
	Provincial Nat. Gas Co. main pipe-line Niagara Falls..........................						2·4

The helium content of most of these gases is about the same as those in Haldimand county but not so high as those in Norfolk county nor is the supply so large.

Peel County

CALEDON TOWNSHIP

At several places in Ontario, small gas fields have been located either in the course of drilling wells for water or in the search for oil. One area which was examined in 1924 was found to contain gas of the highest helium content so far discovered in Canada. Subsequent investigation in 1925 confirmed the earlier results.

The field is situated about 15 miles north of Brampton and 1 mile north of Inglewood. Four wells have been drilled, one ten years ago,

another a few years ago, and two others three years ago. One of these wells is now plugged.

Comparatively little detailed geological work has been done in this neighbourhood and very little data exist on which estimates of the extent of the field can be made or of the chances of finding large quantities of gas. The wells have never been drawn upon for continuous domestic use and even in the few years that the wells have been drilled the pressures have fallen from about 60 pounds per square inch to 48 pounds. It is claimed, however, that the older wells have been allowed, many times in the past, to blow off for long periods and that the rock pressure has only very slightly fallen off on such occasions.

The particulars of these wells are as follows:—

Well No.	Location	Con.	Lot	Date of drilling	Rock pressure 1924	Open flow	Helium content
						M cu. ft.	cu.ft.perM
1	G. Henry farm.........	1 W.C.R........	4	1910	60	100	7·9
2	" "	1 W.C.R........	5	1922	50	200	8·0
3	J. Graham farm........	1 W.C.R........	6	1922	40	60	8·1
4	" "	1 W.C.R.	6	1924	Well abandoned		

An analysis of the gas from this field, together with analyses of the other richest helium-bearing gases in Canada and of the natural gas treated in the United States Government helium extraction plant at Fort Worth, Texas, is as follows:—

Constituents	Caledon field, Ont.,	Woodhouse field, Ont.	Bow Island, Alberta	Petrolia field, Texas
	per cent	per cent	per cent	per cent
Methane (CH_4)..............................	84·4	87·6	89·55	55·34
Ethane (C_2H_6)..............................	3·0	4·9	1·90	11·66
Oxygen (O_2)..............................	trace	0·4	0·21	trace
Carbon dioxide (CO_2)......................	trace	0·1	0·10	0·34
Nitrogen (N_2)..............................	12·1	7·62	7·91	31·72
Helium (He)..............................	0·8	0·38	0·33	0·94

Amount of Helium Available

Until further wells have been drilled in the area to determine the extent of the field, and the depth, thickness and porosity of the gas sands, it is impossible to make any estimate of the quantity of gas that is available for treatment, particularly as the wells have never been drawn upon for continuous use and the rate of decline of flow and pressure under such conditions is unknown.

Assuming, however, that 25 per cent of the total open flow could be taken daily for a year or a larger quantity for a shorter period, and allowing an efficiency of 80 per cent in the process, it is possible that 600 cubic feet of helium a day might be separated. This would mean treating about

4,000 cubic feet of natural gas an hour and would give a yearly production of approximately 200,000 cubic feet. Such a quantity would cover the present demand for scientific and industrial research work, but of course would be a negligible amount as regards a supply for large airships.

The Government of Ontario has lately purchased a number of gas leases in this area and it is possible that the University of Toronto may, with the help of the National Research Council, extract sufficient helium from the Inglewood gas to supply the demands for the low temperature research being carried on in the cryogenic division of the Physics department under Prof. J. C. McLennan.

NEW BRUNSWICK[1]

In Albert and Westmorland counties, New Brunswick, surface indications of oil were recognized as early as 1859 and from that date to 1906 spasmodic efforts were made to develop an oil field. In 1906 the New Brunswick Gas and Oil Fields, Limited, controlled by English capital, took over the fields and this company has operated continuously ever since, producing both gas and oil. The three fields in which oil has been obtained at one time or another are the St. Joseph field, situated 2 miles south of Memramcook; the Dover field, $2\frac{1}{2}$ miles south and east of the village of Dover and near the Petitcodiac river; and the Stony Creek field, the only field at present being operated.

The Stony Creek Field

This field is located in Albert county on the west bank of the Petitcodiac river on the west side of the Moncton-Hillsboro highway, about 9 miles south and a little east of Moncton and about 4 miles north of Hillsboro. The area in which the majority of the wells have been drilled is about 2 miles in length in a direction parallel to the river and about 4 miles in depth.

About seventy wells have been drilled and about thirty are now productive of gas or oil. A certain amount of new drilling has been carried on each year but no new fields have yet been located.

Most of the wells are drilled to depths varying from 2,000 to 2,500 feet. The gas horizons are found in sandstone beds in the Albert series.

The gas is piped to Moncton and to Hillsboro for domestic consumption, the total amount used being approximately 600,000 M cubic feet in 1924.

Helium Content and Composition of the Gas

The field was visited in September, 1925, and a number of gas samples from the different productive horizons and from as many different sources as possible were taken.

The helium content varied widely from 0·001 per cent to 0·069. No theories can be advanced to account for these differences. The following table gives the main points of the information obtained.

[1] Mines Branch, Dept. of Mines, Canada, "Natural Gas in New Brunswick"; Invest. Min. Res. and Mg. Ind., 1925.
Wright, W. J.: Geology of Moncton Map-area; Mem. 129, Geol. Surv., Canada (1922).

Well No.	Depth of gas sands—feet	Rock pressure	Sp. Gr.	Helium content
		lb. per sq.in.		cu. ft. per M
9	....	52	0·669	0·25
12	1,856, 1,886, 1,935	415	0·654	0·35
14	977, 1,319–1,328, 1,365–1,378, 1,395–1,410, 1,458–1,465, 1,480–1,484	78	....	0·48
22	....	17	0·671	0·05
24	....	22	0·672	0·01
41	....	85	....	0·66
6	1,615–1,655, 1,805–1,820, 2,147–2,164, 2,271–2,275, 2,422–2,470, 2,589–2,634	505	0·650	0·69
68	1,318, 2,243	85	0·698	0·33
70	1,564–1,663, 1,746, 1,963	498	....	0·14
71	....	....	....	0·48
72	2,108–2,131	....	....	Nil
72	2,053	....	....	Nil
	Regulator station	....	0·675	0·07

The gas from all of the wells is very similar in composition, having as its chief constituents about 75 to 80 per cent methane and 20 per cent ethane, and 2 to 7 per cent nitrogen. It will readily be seen that the field is of no commercial value for the extraction of helium.

Analyses of Natural Gas in Alberta

Wells	Location				Rock pres. lbs.	Open flow M cu. ft	Producing formation	Depth feet	Date sampled	Constituents					Sp. Gr.	Calorific value B.T.U. at 0°C., 760 mm.	Helium per cent.
	Sec.	Tp.	R.	Mer.						CH_4	C_2H_4	CO_2	O_2	N_2			
Peace River Field																	
Canadian Petroleums Well No. 1	11	85	21	W 5	......	......	Lower Cretaceous Loon River	545, 1,258	10/9/24	78·2	14·8	2·2	....	4·8	0·758	1,109	0·004
Tar Island Oil and Gas Co. Well No. 1	24	85	21	W 5	......	......		860, 980	10/9/24	76·1	1·0	18·8	....	4·1	0·750	830	0·006
Victory Oil Co. Well No. 1	31	83	21	W 5	......	......		1,542	6/9/24	81·4	2·7	15·5	0·3	0·1	0·714	917	0·012
Athabaska River Field																	
Athabaska Landing	21	66	22	W 4	50	Small	Lower Cretaceous Clearwater Shales	780	24/9/24	94·8	2·0	0·3	0·5	2·4	0·570	1,047	0·022
Pelican Rapids Upper Well No. 1	32	77	17	W 4	225	4,500		850	1/10/24	97·8	1·3	0·8	0·1	....	0·579	1,066	0·016
Pelican Rapids Lower Well No. 1	31	78	17	W 4	300	2,000		820	7/16	83·5	......	1·0	2·9	12·6	0·636	850	0·012
Viking Field																	
Northwestern Utilities Well No. 6	6	49	12	W 5	600	7,000	Lower Benton	2,200	2/10/23	92·5	3·5	0·5	0·1	3·4	0·64	1,051	0·006
Wainwright Field																	
British Petroleums Well No. 1	36	45	7	W 4	......	......	Benton and Lower Cretaceous	2,010	4/10/23	87·3	4·4	0·3	1·0	7·0	0·62	1,012	......
British Petroleums Well No. 3	29	45	6	W 4	......	......		2,140	7/10/24	86·8	10·8	0·1	0·1	2·2	0·611	1,126	0·082
British Petroleums Well No. 4	30	45	6	W 4	300	600		2,036	7/10/24	92·2	2·9	0·3	0·2	4·4	0·584	1,036	0·109
Maple Leaf Oil Co. Well No. 1	24	45	8	W 4				1,720	8/10/24	90·0	7·2	nil	0·1	2·7	0·599	1,091	0·096
Maple Leaf Oil Co. Well No. 1	24	45	8	W 4	700	2,500		352	8/10/24	94·1	4·0	0·2	....	1·7	0·579	1,076	0·076
Imperial Oil Co. Fabyan No. 1	18	45	7	W 4	600	10,000		2,205	3/10/23	88·6	2·6	0·3	0·8	7·7	0·61	992	0·06
Medicine Hat and Many Island Lake Fields																	
Medicine Hat City gas mains	....	12-13	5–6	W 4	450	......	Milk River Sandstone	800, 1,000	15/10/23	97·8	0·3	0·4	....	1·5	0·565	1,046	0·116
Canadian-American Oil Co., Well No. 1	19	14	1	W 4	350	500		1,200	18/10/23	96·3	0·5	0·5	0·3	2·4	0·578	1,074	0·067
Medicine Hat Development Co. Well No. 1	19	14	1	W 4	......	800		1,350	18/10/23	95·6	nil	0·2	0·1	4·1	0·574	1,017	......
Community Oils Well No. 1	19	14	1	W 4	......	......		2,471	1922	95·3	......	0·9	....	3·8	0·567	1,015	......

Bow Island Field																
Can. West. Nat. Gas, Light, Heat and Power Co. Well No. 3	9	11	11	W 4	200	1,500	Sandstone beds in the Benton	1,887	24/3/25	89·4	2·8	0·4	....	7·4	0·602	1,004	0·298
Can. West. Nat. Gas, Light, Heat and Power Co. Well No. 4	17	11	11	W 4	200	1,900		1,879	24/3/25	91·2	1·0	......	0·2	7·6	0·591	990	0·291
Can. West. Nat. Gas, Light, Heat and Power Co. Well No. 9	24	11	12	W 4	200	1,800		1,911	24/3/25	88·6	2·3	......	0·4	8·7	0·604	987	0·337
Can. West. Nat. Gas, Light Heat and Power Co. Well No. 19	25	10	12	W 4	178	623		2,146	24/3/25	89·1	1·6	......	0·2	9·1	0·609	979	0·333
Can. West. Nat. Gas, Light, Heat and Power Co., Composite sample	Calgary City mains				......	......		....	1914	91·6	......	......	0·2	8·2	0·59	976	0·30
Can. West. Nat. Gas, Light, Heat and Power Co., Composite sample	Calgary City mains					......		....	1919	90·3	......	......	....	9·7	0·60	962	......
Chin Coulee Field																
Can. West. Nat. Gas, Light, Heat and Power Co. Well No. 1	31	9	17	W 4	600	4,000	Lower Benton	2,166	24/3/25	84·8	1·6	0·2	1·1	12·3	0·621	933	0·386
Can. West. Nat. Gas, Light, Heat and Power Co. Well No. 25	31	9	17	W 4	200	787		....	1917	87·9	3·7	......	....	8·4	......	1,005	0·36
Foremost Field																
Can. West. Nat Gas Co. Well No. 1	1	6	11	W 4	600	17,000	Lower Benton	2,191	20/3/25	90·9	0·6	......	....	8·5	0·592	979	0·225
Can. West. Nat. Gas. Co. Well No. 4	12	6	11	W 4	700	20,000		2,100	30/3/25	97·0	0·5	0·3	....	2·2	0·644	1,043	0·213
Sweet Grass Field																
Canadian Oil and Refining Co., Well No. 1	29	1	11	W 4	900	20,000	....	2,530	24/4/24	94·0	1·8	0·8	0·4	3·0	0·571	1,034	0·094
Turner Valley Field																
Southern Alberta Oil Co. Well No. 2	18	20	2	W 5	......	1,000	....	3,575	19/9/23	52·0	45·1	1·4	0·8	0·7	0·86	1,392	......
Illinois-Alberta Oil Co. Well No. 1	12	20	2	W 5	800	2,000	....	3,038	19/9/23	67·4	30·0	1·0	0·2	1·4	0·72	1,276	......
McLeod Oil Co. Well No. 1	1	20	3	W 5	......	......	....	2,397	–/4/25	32·1	66·4	1·1	0·5	0·0	0·891	1,578	......
Royalite Oil Co. Well No. 1	20	20	2	W 5	......	2,000	Kootenay	3,910	20/9/23	71·8	25·9	2·1	0·3	0·9	0·70	1,248	0·03
Royalite Oil Co. Well No. 3	....	20	2	W 5	......	3,000		2,830	20/9/23	67·2	30·3	1·7	....	0·8	0·71	1,280	0·061
Royalite Oil Co. Well No. 4	7	20	2	W 5	1,100	20,000	Triassic(?)	3,740	–/4/25	69·6	26·7	1·8	0·5	1·4	0·712	1,239	0·009
Miscellaneous																
Coalspur Imp. Oil Co. Well No. 2	3	49	21	W 5	......	76	....	890	28/10/24	66·2	29·6	0·8	....	3·4	0·727	1,256	0·024
Coalspur Imp. Oil Co. Well No. 2	....	....	....	......	......	350	....	2,020	25/10/24	70·6	15·5	1·9	....	12·0	0·690	1,041	0·022
Craigmyle Prairie Nat. Gas Co. Well No. 1	36	32	17	W 4	25	......	Upper Cretaceous	390	17/ 9/23	95·4	......	0·3	....	3·7	0·57	1,016	......
Pigeon Lake Globe Drilling Co.	14	47	27	W 4	......	......		380, 900	21/10/24	93·0	2·8	......	0·8	3·4	0·571	1,042	0·022

Analyses of Natural Gas in Ontario

Lab. No.	Township	Well	Con.	Lot	Producing formation	Depth feet	Date collected	Constituents							Specific gravity (air = 1)	Calorific value B.T.U. at 0°C., 760 mm.	Helium per cent
								CH_4	C_2H_6	C_3H_8	CO_2	O_2	N_2	H_2S			
	Lambton County																
6	Sarnia.........	L. Wilson, Craig No. 1........	7	13	Onondaga......	465	1924	....	....	....	....	....	....	....	0·744	......	0·06
100	"	" Griffin No. 1......	7	8	"	470	1925	54·5	36·7	....	0·6	....	8·2	....	0·781	1,263	0·07
7	"	" Griffin No. 2......	7	8	"	471	1924	....	....	....	....	....	....	....	0·693	......	0·20
8	"	" Blunden No. 1.....	7	19	"	585	1924	....	....	....	....	....	....	....	0·739	......	0·04
5646	"	Dominion Alloy Steel.........	R.R.	2	"	100	1925	95·9	1·4	....	0·2	....	2·5	....	0·584	992	0·03
10	Enniskillen.....	Oil Springs Gas Co. Well No. 7..........................	2	19	Trenton........	3,571	1924	....	....	....	....	....	....	....	0·615	......	0·19
11	"	Oil Springs Gas Co. Well No. 6......................	2	19	White Medina...	2,035	1924	....	....	....	....	....	....	....	0·690	......	0·19
1A	"	Fairbanks well................	2	18	" ..	1,898	1914–16	68·3	12·5	3·4	....	....	15·8	....	0·714	1,049	0·15
1B	"	Oil Springs Gas Co. Well No. 2......................	2	18	....	1,800	1914–16	69·0	15·7	1·8	....	....	13·5	....	0·705	1,077	0·14
L3	Euphemia......	Lambton No. 3..............	4	26	....	1,600	1914	80·2	11·7	....	....	....	8·1	....	0·646	1,072	....
12	Dawn..........	Union Nat. Gas Co. Well No. 7......................	8	25	Niagara........	1,842	1924	75·8	14·4	....	0·5	....	9·3	....	0·670	1,076	0·29
104	"	Union Nat. Gas Co. Well No. 6......................	5	24	"	1,905	1925	....	....	....	....	....	....	....	0·657	......	0·21
105	"	Union Nat. Gas Co. Well No. 4......................	4	23	"	1,614	1925	....	....	....	....	....	....	....	0·674	......	0·18
108	"	Union Nat. Gas Co. Well No. 3......................	5	24	"	1,615	1925	....	....	....	....	....	....	....	0·685	......	0·14
106	"	Union Nat. Gas Co. Well No. 1......................	7	24	"	1,580	1925	72·3	19·3	....	0·5	....	7·8	....	0·686	1,129	0·14
	Kent County																
15	Dover.........	Union Nat. Gas Co. Well No. 13.....................	3	3	Trenton........	3,000	1924	88·6	8·6	....	....	....	2·7	....	0·628	1,104	0·13
18	Tilbury East..	Union Nat. Gas Co. Well No. 112....................	14	8	Guelph or Salina	1,398	1924	....	....	....	....	....	....	....	0·630	......	0·08
2B	" ..	Union Nat. Gas Co. Askew Well......................	L.F.	173	" "	1,372	1914–16	84·4	10·8	....	....	....	4·5	0·3	0·625	1,101	0·18

A	"	Union Nat. Gas Co. Haliday Well	13	10	" "	1,260 1,383	1914–16	83·4	10·6				5·3	0·4	0·626	1,086	0·11
17	Romney	Union Nat. Gas Co. Haliday Well No. 216	L.F.	183	" "	1,285	1924								0·622		0·19
K3	"	Union Nat. Gas Co. Baldwin Well	L.F.	185	" "	1,140 1,380	1914	86·0	8·5				4·8	0·6	0·612	1,074	
13	Raleigh	Union Nat. Gas Co. Declout	Talbot	146	" "		1924								0·651		0·11
14	"	Union Nat. Gas Co. Well No. 105	"	162	" "	1,405	1924								0·650		0·10
K1	"	Union Nat. Gas Co., Baker Farm	"	161	" "	1,420	1914	76·1	18·0		0·1		5·8	tr.	0·669	1,146	
9	Howard	Union Nat. Gas Co., Bennett No. 2	11	4	Surface	100	1924								0·739		0·03
		Pipe-line gas, Port Alma (unpurified)					1925	84·1	11·1		0·3	0·8	3·7	0·5	0·631	1,103	0·11
		Pipe-line gas, pipe-line to Sarnia					1923	87·6	5·5	1·4			5·0	0·5	0·611	1,036	
	Essex County																
16	Gosfield, S.	B. Jasperson well, Kingsville	1	2–3	Guelph or Salina	900	1924								0·630		0·15
E1	"	Fox farm	1	7	" "	1,020	1914	87·6	7·3				4·8	0·3	0·609	1,070	
	Elgin County																
El 1	Bayham	R. Balcom No. 1	Vienna		Clinton	1,330	1914	84·1	10·8				5·1		0·629	1,097	
109	"	Medina Gas Co., Main line	"		"		1925	78·8	13·9		0·6		6·7		0·654	1,094	0·25
110	"	" " Richmond No. 1	5	1	"	1,275	1925								0·638		0·26
111	"	" " Well No. 2	2	14	"	1,398	1925								0·630		0·22
112	"	" " Well No. 5	3	10	"	1,308	1925								0·646		0·24
	Norfolk County																
21	Walsingham, S.	Dominion Gas Co., Port Rowan	8	12	Clinton	1,271	1924								0·621		0·37
N1	"	J. R. Buck Well, Port Rowan	Village		Medina	1,420	1914	84·4	6·8				8·8		0·624	1,025	
N2	"	E. Foster Well, Port Royal			"	1,410	1914	83·8	7·7				8·5		0·648	1,025	
22	" N.	Dom. Gas Co., J. B. Brown No. 1	14	21	Clinton	1,175	1924								0·654		0·38
23	Windham	Dom. Gas Co., Charlton No. 1	13	24	"	1,113	1924								0·654		0·33
N3	Woodhouse	Well in Port Dover			White Medina	1,013	1914	75·8	14·2				10·0		0·666	1,072	
19	"	Port Dover Town Well	1	12	Red Medina	961	1924								0·669		0·34
20	"	Dom. Gas Co., Port Ryerse, Boyd	1B.F.	12	"	1,100	1924	88·4	6·2		0·1	0·8	4·5		0·644	1,057	0·43
113	"	Dom. Gas Co., Wedlake, Port Dover			Clinton	1,018	1925								0·657		0·32

Analyses of Natural Gas in Ontario—*continued*

Lab. No.	Township	Well	Con.	Lot	Producing formation	Depth feet	Date collected	Constituents CH₄	C₂H₆	C₃H₈	CO₂	O₂	N₂	H₂S	Specific gravity (air=1)	Calorific value B.T.U. at 0°C., 760 mm.	Helium per cent
	Norfolk County—Con.																
114	Woodhouse	Dom. Gas Co., Dixon No. 1	1	7	Red Medina	1,021	1925	78·5	10·2	....	0·2	....	11·1	....	0·639	1,022	0·42
120	"	Dom. Gas Co., H. Williams	B.F.	4	Red and White Medina	1,058	1925	....	....	....	....	....	....	....	0·620	....	0·45
121	"	Dom. Gas Co., W. Holloway	4	6	Clinton and Red Medina	990	1925	....	....	....	....	....	....	....	0·661	....	0·30
122	"	Dom. Gas Co., J. Livesay No. 1	3	7	Red Medina	1,039	1925	....	....	....	....	....	....	....	0·662	....	0·35
123	"	Dom. Gas Co., P. Boulter	2	7	Clinton and Red Medina	1,027	1925	....	....	....	....	....	....	....	0·657	....	0·39
128	"	Dom. Gas Co., W. Mitchell	6	15	Clinton and White Medina	{ 890 930	1925	....	....	....	....	....	....	....	0·606	....	0·42
116	Middleton	Dom. Gas Co., J. Fisher No. 1	2	16	Clinton	1,253	1925	....	....	....	....	....	....	....	0·626	....	0·27
117	"	Dom. Gas Co., A. Teller	2	15	Clinton	1,246	1925	....	....	....	....	....	....	....	0·694	....	0·29
126	"	Dom. Gas Co., A Quance	2	43	Clinton	1,109	1925	73·8	13·1	....	0·3	0·2	12·6	....	0·660	1,025	0·39
119	Charlotteville	Dom. Gas Co., L. Oakes	3	24	Clinton	1,129	1925	....	....	....	....	....	....	....	0·664	....	0·38
125	"	Dom. Gas. Co., Roberts No. 1	11	4	Clinton	1,204	1925	....	....	....	....	....	....	....	0·662	....	0·40
127	Townsend	Dom. Gas Co., Yomans No. 1	14	16	Clinton and White Medina	....	1925	77·5	6·4	....	0·6	0·4	15·1	....	0·648	945	0·52
124	....	Pipe-line gas, Simcoe from Delhi-Lynedoch field	....	....	....	....	1925	69·7	12·2	....	0·5	0·1	17·5	....	0·690	966	0·38
115	....	Pipe-line gas, Simcoe from Woodhouse tp	....	....	....	....	1925	74·6	14·1	....	0·5	....	10·8	....	0·668	1,052	0·39
25	....	Pipe-line gas, Simcoe	....	....	....	....	1924	86·9	3·7	....	0·2	....	9·2	....	0·654	995	0·39
	Brant County																
B1	Onondaga	Cockshutt Plow Works well	....	....	Medina	550	1914	76·9	8·0	1·2	....	0·1	13·8	....	0·662	969	....
B2	"	Wm. Macdonald farm	2	6	White Medina	{ 400 515	1914	68·6	19·0	....	....	....	12·4	....	0·700	1,084	....
B3	"	Wm. Brette farm	3	6	Clinton	400	1914	74·6	15·4	....	....	....	10·0	....	0·673	1,082	....

4A	....	Pipe-line gas, Onondaga main, taken at Brantford........	....	....	....	......	1916	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·25
4D	....	Pipe-line gas, Onondaga–Middleport main........	....	....	....	......	1916	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·32
24	Oakland........	H. Hunter Well No. 1........	1	2	Clinton.........	730	1924	.....	.....	.....	.....	.....	.....	.....	0·652	.....	0·31
	Haldimand County																
37	Walpole........	Dom. Gas. Co., Laidlaw Well No. 2........	7	18	Clinton.........	790	1924	85·5	1·34	.....	.....	.....	1·1	....	0·625	1,161	0·33
38	"	Dom. Gas Co., Shoup Well No. 1........	3	14	White Medina...	1,005	1924	.....	.....	.....	.....	.....	.....	....	0·651	.....	0·30
H9	"	Dom. Gas Co., J. Steele farm	1	18	Red Medina....	782	1914	84·9	8·3	.....	.....	.....	6·8	....	0·624	1,059	....
142	"	Dom. Gas Co., E. A. Wright..	8	16	Red Medina....	800	1925	.....	.....	.....	.....	.....	.....	....	0·637	.....	0·29
143	"	Dom. Gas Co., W. Edsel......	Peacock pt.	15	Clinton.........	900	1925	.....	.....	.....	.....	.....	.....	....	0·638	.....	0·26
141	"	Pipe-line between 5th and 6th Con. fed by 12 wells........	....	....	....	......	1925	.....	.....	.....	.....	.....	.....	....	0·657	.....	0·28
140	"	Gas from regulating station, Selkirk........	....	....	....	......	1925	77·1	12·8	.....	0·5	0·1	9·5	....	0·662	1,058	0·35
154	"	Gas from Selkirk-Caledonia pipe-line........	....	....	....	......	1925	75·6	14·8	.....	0·2	....	9·4	....	0·657	1·081	0·26
29	Rainham.......	Dom. Gas Co., W. Austin well	1	24	Clinton.........	850	1924	.....	.....	.....	.....	.....	.....	....	0·654	.....	0·26
H11	"	Lake Erie Water lot, Crown lease........	1	5	Clinton.........	830	1914	77·8	14·7	.....	.....	.....	7·5	....	0·658	1,103	....
145	"	Dom. Gas Co., J. J. Hoover Well No. 1........	1	2	Red Medina....	815	1925	.....	.....	.....	.....	.....	.....	....	0·648	.....	0·28
146	"	Dom. Gas Co., G. Nagel Well No. 1........	2	13	Clinton.........	790	1925	.....	.....	.....	.....	.....	.....	....	0·664	.....	0·24
144	"	Dom. Gas Co., 6″ line, Rainham road between 1st and 2nd Con........	....	....	....	......	1925	.....	.....	.....	.....	.....	.....	....	0·626	.....	0·30
26	Cayuga, S......	Dom. Gas Co., H. Kramp....	6	18	Clinton.........	800	1924	.....	.....	.....	.....	.....	.....	....	0·654	.....	0·28
H6	"	W. Pridmore farm........	5	22	Red Medina....	785	1914	81·8	11·8	.....	.....	.....	6·4	....	0·640	1,092	....
H7	"	Jas. Topp farm........	....	....	Red Medina....	700	1914	76·6	16·3	.....	.....	.....	7·1	....	0·665	1,119	....
28	Dunn...........	Dom. Gas Co., J. Bowden, Earlstract........	16, 17	18	Clinton.........	......	1924	.....	.....	.....	.....	.....	.....	....	0·651	.....	0·30
H1	"	Port Maitland........	3	25	White Medina..	880	1914	67·8	16·0	3·5	.....	.....	12·7	....	0·720	1,019	....
H2	"	H. P. Docker farm........	4	18	Red Medina....	930	1914	79·7	11·4	.....	.....	.....	8·9	....	0·648	1,061	....
32	Moulton........	Dom. Gas Co., W. Burch Well........	N. Forks	15	White Medina...	676	1924	.....	.....	.....	.....	.....	.....	....	0·652	.....	0·27
34	"	Dom. Gas Co., F. Speck......	2	1	....	......	1924	.....	.....	.....	.....	.....	.....	....	0·661	.....	0·26
129	"	Dom. Gas Co., W. Dolan.....	1	15	....	......	1925	.....	.....	.....	.....	.....	.....	....	0·657	.....	0·26
130	"	Dom. Gas Co., C. Ackland...	2	15	White Medina...	720	1925	.....	.....	.....	.....	.....	.....	....	0·651	.....	0·30
136	"	Dom. Gas Co., A. Riley......	N. Forks	24	....	......	1925	.....	.....	.....	.....	.....	.....	....	0·670	.....	0·22
135	"	Maple Leaf Co., F. Dicont....	3	10	....	......	1925	.....	.....	.....	.....	.....	.....	....	0·663	.....	0·24

Analyses of Natural Gas in Ontario—*continued*

Lab. No.	Township	Well	Con.	Lot	Producing formation	Depth feet	Date collected	Constituents CH_4	C_2H_6	C_3H_8	CO_2	O_2	N_2	H_2S	Specific gravity (air=1)	Calorific value B.T.U. at 0°C., 760 mm.	Helium per cent
	Haldimand County—Con.																
29	Canborough....	Dom. Gas Co., C. VanKuren.	3	5	White Medina...	650	1924	....	....	....	....	....	....	....	0·658	......	0·26
30	"	Dom. Gas Co., J. M. Allen....	2	14	....	......	1924	....	....	....	....	....	....	....	0·652	......	0·33
31	"	Dom. Gas Co., H. A. Lymburner..........	3	3	....	......	1924	....	....	....	....	....	....	....	0·666	......	0·27
132	"	Dom. Gas Co., T. Finch No. 1	1	15	White Medina...	535	1925	....	....	....	....	....	....	....	0·640	......	0·38
133	"	Dom. Gas Co., J. Potts No. 2	1	11	White Medina...	600	1925	....	....	....	....	....	....	....	0·645	......	0·26
131	"	Main line Canboro Gas and Oil Co., meter house........	....	....	....	......	1925	....	....	....	....	....	....	....	0·644	......	0·31
139	"	Bird Road regulating station	....	....	....	......	1925	....	....	....	....	....	....	....	0·670	......	0·22
137	"	Winger regulating station.....	....	....	....	......	1925	75·8	14·2	....	0·3	....	9·7	....	0·654	1·072	0·31
H5	Cayuga, N.....	Dom. Nat. Gas Co., Well No. 162, North Grand river....	....	....	Red Medina....	630	1914	79·4	14·3	....	....	....	6·3	....	0·651	1,112	....
H8	"	Dom. Nat. Gas Co. Well No. 161, River road...........	....	8	Red Medina....	600	1914	76·3	15·4	....	....	....	8·3	....	0·665	1,100	....
140	"	Dom. Nat. Gas Co., C. K. Medlicott..................	3	7	Clinton and Red Medina.......	590 625	1925	....	....	....	....	....	....	....	0·636	......	0·35
46	Oneida....	Dom. Gas Co., W. Martin No. 1.....................	3	24	Clinton........	680	1924	....	....	....	....	....	....	....	0·664	......	0·32
47	"	Dom. Gas Co., J. Thompson No. 1.....................	R.R.	64	Medina.........	543	1924	....	....	....	....	....	....	....	0·681	......	0·34
152	"	Dom. Gas Co., P. Yuile No. 1	B.F.	38	Clinton and White Medina	589	1925	78·0	12·1	....	0·2	....	9·7	....	0·655	1,057	0·32
149	"	Collecting line feeding Selkirk-Caledonia pipe-line........	....	....	....	......	1925	....	....	....	....	....	....	....	0·643	......	0·31
51	Seneca.........	Dom. Gas Co., W. Robinson..	2	15	....	......	1924	....	....	....	....	....	....	....	0·654	......	0·29
49	"	Dom. Gas Co., 15 wells in....	5	....	Clinton........	......	1924	84·4	11·1	....	....	....	4·5	....	0·649	1,105	0·32
H12	"	S. McLeod farm.............	4	13	"	397 497	1914	80·0	11·4	....	....	....	8·6	....	0·646	1,064	....
148	"	A. Emerson..................	Young's tract	3	Clinton and Red Medina.......	523 589	1925	....	....	....	....	....	....	....	0·646	......	0·26

149	Seneca and Oneida	4-inch pipe-line to Blackheath			Clinton and Red Medina		1925								0·643		0·31
	Welland County																
33	Wainfleet	Dom. Gas Co., W. Wills	5	31	Medina		1924								0·664		0·34
138	"	" J. Snyder	5	30	"		1925								0·704		0·26
39	Humberstone	Port Colborne Gas Co., Menoah No. 1	3	31	"		1924								0·700		0·25
41	"	Port Colborne Gas Co., pipe-line to Port Colborne			"		1924								0·664		0·31
W1	"	Well	2	13	White Medina	830	1914	74·8	17·3				7·9		0·622	1,119	
43	Humberstone and Bertie	Main pipe-line to Niagara Falls					1924								0·682		0·24
42	Bertie	Prov. Nat. Gas Co. Pt. Abino Well			White Medina	902	1924	83·4	8·4				8·2		0·670	1,044	0·34
6A	"	Prov. Nat. Gas Co. Pt. Abino Well					1916										0·26
42(*a*)	"	Prov. Nat. Gas Co. Well No. 471	13	7	Medina	700 800	1924								0·640		0·23
W2	"	Prov. Nat. Gas Co. Well	1	34	White Medina	888	1914	80·0	12·9			0·2	7·1		0·648	1,091	
W3	"	" "	14	12	Clinton	578	1914	82·1	13·5				4·4		0·638	1,126	
W4	"	" "	5	15	"	565	1914	83·6	12·0	0·1	0·1		4·2		0·632	1,113	
6D	"	Prov. Nat. Gas Co. Well No. 382					1916										0·28
44	Willoughby	Prov. Nat. Gas Co. Well No. 61	4	2	Trenton	2,940	1924								0·579		0·09
W5	"	Prov. Nat. Gas Co. Well No. 61	4	2	"	2,940	1914	93·7	3·3	0·2	0·1		2·7		0·583	1,059	
6F	"	Prov. Nat. Gas Co. Well No. 61	4	2	"	2,940	1916										0·11
45	Crowland	Prov. Nat. Gas Co. Well No. 199	4	3	Clinton	700	1924								0·662		0·25
W7	"	Prov. Nat. Gas Co., G. Jenkinson's farm	4	7	Clinton and White Medina	550	1914	85·9	8·7				5·4		0·619	1,077	
		Main pipe-line, Niagara Falls, average 7 analyses					1923	79·8	9·0	1·8			9·4		0·655	1,017	0·24
	Lincoln County																
134	Caistor	Dom. Gas Co., W. C. Lymburner			Clinton and White Medina	422 522	1925								0·656		0·24
156	"	6-inch line to Blackheath			Clinton and White Medina		1925								0·646		0·26
	Wentworth County																
48	Binbrook	Prov. Nat. Gas Co., W. Beattie	9	26	Red and White Medina	395 460	1924								0·664		0·35

Analyses of Natural Gas in Ontario—*concluded*

Lab. No.	Township	Well	Con.	Lot	Producing formation	Depth feet	Date collected	Constituents CH$_4$	C$_2$H$_6$	C$_3$H$_8$	CO$_2$	O$_2$	N$_2$	H$_2$S	Specific gravity (air=1)	Calorific value B.T.U. at 0°C., 760 mm.	Helium per cent
	Wentworth County—Con.																
50	Binbrook......	Prov. Nat. Gas Co., H. Johnston..........	4	5	Red and White Medina.......	430	1924	.....	.....	.....	.....	.....	.....	.....	0·705	......	0·21
151	"	Dom. Nat. Gas Co., J. Berry No. 1..........	9	31	Clinton and White Medina	......	1925	.....	.....	.....	.....	.....	.....	.....	0·620	......	0·33
157	"	Gas from Blackheath regulating station..........	....	....	Clinton and White Medina	......	1925	.....	.....	.....	.....	.....	.....	.....	0·661	......	0·31
155	Glanford.......	Dom. Nat. Gas Co., J. Walker, No. 3..........	8	14	Clinton.........	363	1925	.....	.....	.....	.....	.....	.....	.....	0·660	......	0·25
	Peel County																
1	Caledon, W.....	G. Henry farm, Well 1........	1 W.C.R.	4	Hudson shale...	350 500 935	1924	84·0	4·0	.....	....	....	12·0	....	0·623	969	0·79
2	"	G. Henry farm, Well 2........	1 W.C.R.	5	....	590	1924	84·8	2·0	.....	....	....	14·2	....	0·786	940	0·80
3	"	J. Graham farm, Well 1.......	W.C.R.	6	....	545	1924	84·4	3·0	.....	....	....	12·6	....	0·630	965	0·82
	Simcoe County																
4	Tecumseth.....	M. Jackson farm..............	....	1	Surface.........	250	1924	77·9	....	.....	0·9	....	21·2	....	0·648	830	0·01

*Sources of data:—

Mines Branch Rept. 522, Report on Some Helium Resources of the British Empire. Prof. J. C. McLennan. Analyses of samples collected in 1916, denoted by numeral followed by letter.

Ontario Bureau of Mines. Ann. Rept. 1914, Vol. 23, pp. 237–273. The chemical composition of natural gas found in Ontario. G. R. Mickle. Analyses made in 1914 by Prof. W. H. Ellis, J. W. Bain, and E. G. R. Ardagh, University of Toronto, denoted by initial letter of county followed by number.

Mines Branch Investigations on Natural Gas. Analyses by R. T. Elworthy and R. J. Offord, denoted by numerals. Samples collected in 1924 and 1925.

August, 1925.

SUMMARY OF AVAILABLE SUPPLY OF HELIUM

In the following summary of the estimates that have been made in the previous pages of the possible recovery of helium from natural gas at two points in Alberta and at four points in Ontario the assumption is of course made that helium can be extracted from gases containing as little as 2·0 cubic feet per thousand with an efficiency of at least 80 per cent of the theoretically possible recovery.

The question of costs is not considered here.

The quantity is as follows:—

Field	Location of station	Quantity of natural gas available per annum M. cu. ft.	Helium content cu. ft. per M.	Helium recoverable per annum cu. ft.
Foremost, Alta	Foremost or Burdette	1,200,000	2·0	2,000,000
Bow Island, "	Burdette	526,424	3·0	1,250,000
Norfolk County, Ont	Simcoe	287,790	3·9	900,000
Haldimand County, "	Dunnville	127,139	2·7	275,000
Haldimand County, "	Winger	250,377	2·7	540,000
Peel County, "	Inglewood	30,000	8·0	200,000
Total				5,165,000

REGULATIONS REGARDING CONSERVATION OF HELIUM-BEARING GASES

The Dominion Government controls the petroleum and natural gas rights in Manitoba, Saskatchewan, Alberta, the Yukon Territory, the railway belt in British Columbia and the Northwest Territories. Regulations are made by Order-in-Council and are enforced by the Mining Lands Branch of the Department of Interior.

The following paragraph was incorporated in 1922 into the form of petroleum and natural gas lease as issued by the Mining Lands Branch.

Saving and reserving nevertheless unto His Majesty and his successors the helium of, from, or found combined with, or extractable, or which may be obtained out of, the petroleum and natural gas within or mined, won or produced from or out of the said parcel or tract of land and premises hereinbefore described and granted or demised or intended so to be, together with full power to win, separate and extract the same, and to treat the said petroleum and natural gas or subject the same to any operation or process which may be necessary, effective or advisable for that purpose, and to enter upon, use or occupy the said lands or so much thereof, and to such extent as may be necessary, and to set up and operate any machinery, appliances or plant, and to resort to any process or operation which may be useful for any of the purposes aforesaid. (First paragraph, page 2, form of lease).

The following section 41 of the regulations attached to the lease may also be applied.

41. The Minister may at any time assume absolute possession and control of any location acquired under the provisions of these regulations, if in the opinion of the Government of Canada such action is considered necessary or advisable, together with all buildings, works, machinery and plant, upon the location, or used in connexion with the operation thereof, and he may cause the same to be operated any way and retain the whole or any part of the output, in which event compensation shall be paid to the lessee for any loss or damage sustained by him by reason of the exercise of the powers conferred by this provision of the regulations, the amount of the compensation, in case of dispute, to be fixed by a Judge of the Exchequer Court of Canada, provided that the compensation in any such case shall not exceed the profit which the lessee would have earned in the working of the location and the disposal of the produce thereof, had possession, and control of the location and of the building, works, machinery and plant not been assumed.

In the last session (1925) of the Legislative Assembly of the Province of Ontario the Natural Gas Conservation Act 1921 was amended by adding thereto the following section.

5a. Where the Minister is of the opinion that helium, argon or any other rare gas is found or is capable of production in commercial quantities in any part of the Province, the Minister may give such directions and may make such orders as he may deem proper compelling any owner, lessee or proprietor in such territory to close and keep closed for such time as the Minister may deem necessary any natural gas wells in such territory in such manner that no gas may escape therefrom until such steps may have been taken as the Minister may deem necessary for the extraction and conservation of any such rare gas.

BIBLIOGRAPHY OF NATURAL GAS IN CANADA

Clapp, F. G., and others. Petroleum and Natural Gas Resources of Canada, vols. 1 and 2, Mines Branch, Dept. of Mines (1915).

Elworthy, R. T. Natural Gas in Alberta, Mines Branch, Dept. of Mines, Canada. Invest. Min. Res. and Mg. Ind. 1923 (1924).

Harkness, R. B. Natural Gas and Petroleum section, Ont. Bureau of Mines, Ann. Repts. XXXI, XXXII and XXXIII (1924, 1925, 1926).

Mickle, G. R. Chemical Composition of Natural Gas found in Ontario, Ont. Bureau of Mines, Ann. Rept. XXIII (1915).

Ross, C. C. Petroleum and Natural Gas Development in Alberta, Trans. Can. Inst. of Min. and Met., Vol. 29 (1926).

GEOLOGY

Ontario

Clapp, F. G., and others. Petroleum and Natural Gas Resources of Canada, Vols. 1 and 2, Mines Branch, Dept. of Mines (1915).

Malcolm, Wyatt. The Oil and Gas Fields of Ontario and Quebec, Geol. Surv., Canada, Mem. 81 (1915).

Williams, M. Y. The Silurian Geology of Ontario, Geol. Surv., Canada, Mem. 70 (1924). See also Summary Reports, Geol. Surv., Canada.

Alberta

Dowling, D. B., Slipper, S. E., and McLearn, F. H. Investigations in the Gas and Oil Fields of Alberta, Saskatchewan, and Manitoba, Geol. Surv., Canada, Mem. 116 (1919).

Hume, G. S. The Wainwright Irma Oil and Gas Area, Alberta. Canadian Mining Journal, pp. 1259-1264, Dec. 26th, 1924.

Oil Prospects in the Vicinity of Battle River at the Alberta-Saskatchewan Boundary.

Notes on Developments in the Wainwright Field, Geol. Surv., Canada, Sum. Rept. 1925, Part B.

Slipper, S. E. Sheep River Gas and Oil Field, Alberta, Geol. Surv., Canada, Mem. 122 (1921).

CHAPTER V

THE TECHNOLOGY OF HELIUM

USES OF HELIUM

Helium possesses many remarkable properties which may make it a very useful industrial gas with many commercial applications when supplies are available in sufficiently large quantities and at a price low enough to permit its economic utilization. Up to the present about twenty-five million cubic feet have been separated from natural gas and the greater part of this quantity has been used in United States airships.

Use in Airships

Helium is of value for use in balloons and airships because of its lightness and particularly because of its non-inflammability. The first record of a suggestion of the suitability of helium for this purpose is probably a statement by a German writer, Austerweil,[1] that helium would be the ideal gas for filling balloons and airships but that the idea was a Utopian dream.

Reference has already been made to the realization of this idea and to the history of commercial production of helium for this purpose.

However, helium has only about 88 per cent of the lifting power of hydrogen, and the difference that this makes in the available load of a large airship is very considerable and is one of the chief arguments advanced against its use. The main advantage of helium over hydrogen is that helium is non-combustible. Everyone knows that a mixture of hydrogen and air is exceedingly easily ignited or exploded, depending on the proportions of the mixture. No one who witnessed the destruction and descent in flames of zeppelins in air raids in England during the war, or of observation balloons in France, can fail to realize the great advantage of using helium.

Another possibility that the non-inflammability of helium permits is the arrangement in some way of heating apparatus in or around the gas-bags to expand the gas and increase the buoyancy of the ship at will, or by cooling decrease the lift when it is desired to land.

The rate of diffusion of helium is less than that of hydrogen and on this account it might not be necessary to add make-up gas so frequently when helium is used.

The chief reason why gas in an airship has to be frequently renewed is that after a time a certain amount of air leaks into the gas, thus reducing the lifting power of the gas, be it hydrogen or helium, beyond the safety point. In the case of hydrogen it is cheaper to refill the gas bags with a new supply. Helium is too costly to allow this and the United States authorities have developed cheap methods of purification whereby the contaminated helium can be passed through the purification apparatus and returned to the gas bags without loss. When the relative costs of

[1] Austerweil. Die Angewandte Chemie in der Luftfahrt, p. 8, published by Oldenburgh, Berlin, 1914.

hydrogen and helium are calculated, the fact that perhaps ten supplies of hydrogen per year will be required to one supply of helium plus the costs of six or seven purifications, must be taken into consideration.

Another improvement that the United States officials have developed to conserve helium while flying is the installation of apparatus to condense the water vapour in the exhaust gases from the engines of airships and so maintain as far as possible a constant load. Otherwise helium would have to be valved periodically to compensate for the loss in weight due to the combustion of the motor fuel used.

Much technical discussion has arisen in the United States over the relative merits of helium and hydrogen. The practical experience gained in the operation of the ill-fated United States airship Shenandoah and of the Los Angeles has been of great value and the general opinion[1] seems to be that helium is the only gas to use if sufficient quantities at a reasonably low price can be obtained.

The Shenandoah, built in the United States on the model of the German Zeppelins, was put into commission in 1923 and made many successful, long cruises. The record of its 9,000-mile trip from the Atlantic to the Pacific coast is a most interesting story[2] and demonstrates the possibilities of commercial airship transportation.

It is not believed that any airship could have survived the terrific storm which wrecked it in September 1925 near Ava, Ohio, when fifteen of its crew were killed. Had it been hydrogen-filled it is probable that there would have been no survivors.

The Use of Helium-Oxygen Mixtures in Deep Diving and Caisson Operations

One use of helium that may have great value is its use in making up artificial atmospheres of oxygen and helium to supply to divers and caisson workers.

Dr. R. R. Sayers and W. P. Yant of the U.S. Bureau of Mines have carried out an investigation[3] along these lines which demonstrated its great possibilities. By far the greatest amount of time a diver can spend under water is taken up in his gradual ascension. A diver descending to a depth of 200 feet can work perhaps for thirty minutes, after which he must come to the surface slowly and in stages, taking perhaps 2 hours in his ascent. In the same way workers in caissons, unless slowly decompressed, are liable to serious ill-effects and even death. The cause of this is that the nitrogen of the air pumped down necessarily under pressure is absorbed by the body tissues and fluids in abnormal amounts and if the pressure is released too rapidly the nitrogen comes out of solution too fast to diffuse away and forms bubbles in the tissues, which may have disastrous results.

Helium, having a lower solubility in these fluids and also a greater diffusibility, should not have the ill-effects of nitrogen. Its inert nature is also an advantage. Experiments by the authorities referred to above showed that helium-oxygen atmospheres could be breathed by men without apparent discomfort, and that animals exposed to such artificial airs up

---

[1] Moore, R. B.: Ind. and Eng. Chem., Vol. 18, p. 210 (1926).
[2] Wood, J. B.: Seeing America from the Shenandoah, National Geographic Magazine, Vol. 47, No. 1, Jan. 1925.
[3] U.S. Bureau of Mines, Reports of Investigations No. 2670, Feb. 1925.
Eng. News Record, Vol. 95, No. 15, p. 586, Oct. 8, 1925.

to 10 atmospheres pressure, suffered no ill-effects and could be decompressed in one-third to one-quarter the time necessary when air (a nitrogen-oxygen mixture) was used.

Such helium-oxygen atmospheres have great possibilities, therefore, and may permit of greater depths being attained and longer periods spent under water by divers, and the prevention of caisson disease in tunnel and caisson workers.

Other Uses

On account of the high heat conductivity of helium, combined with its inert character, it has been suggested that certain types of electric generators and motors in the operation of which much heat is generated might be surrounded with a helium atmosphere which would afford a greater rate of cooling than is possible with air, thus permitting of an increased load. Helium might be of value similarly, for use in transformers and high-tension switch-boxes wherever there is any possibility of an inflammable vapour or gas mixture being present which might be ignited by an electric spark. It is probable that these uses have been experimentally investigated and may become applied industrially if and when commercial supplies of helium are available.

The use of helium in searchlights has been suggested on the grounds that heat from the carbon arc would be readily conducted away, and that there would be advantages in its lack of oxidizing power. Small amounts of helium are occasionally used in electric discharge tubes, similar to the neon tubes that are now so widely employed in Europe for advertising purposes and illuminated signs. Helium is not desirable for use in electric light bulbs, which now contain small amounts of nitrogen or argon, as blackening of the bulb occurs due to volatilization and deposition of metal from the filament.

Another suggestion put forward is that helium might be of value in the casting of aluminum and its alloys. Nitrogen is now sometimes used to blow through such castings just before they set to remove other gases which might have a more deleterious effect. It is probable that helium is much less soluble than nitrogen in molten metals and has the added advantage that it will not form any compound with the metals.

Although a study of the properties of the various elements at the temperature of liquid helium is of the utmost scientific importance it is not probable that the low temperature so obtainable will have any industrial applications other than might be obtained more easily by the use of liquid hydrogen.

It is probable, therefore, that the properties of inertness, lightness, and high heat conductivity may make helium of great industrial importance. However, few applications have yet been considered owing to the restriction on its exportation from the United States and the relatively small amounts of helium available for large-scale industrial experiment even in that country.

EXTRACTION PROCESSES

Although at least four experimental plants and one large-scale plant in the United States and one experimental installation in Canada have been operated for the extraction of helium from natural gas the same general principles have been employed in each. It is not proposed to enter into

details here but only to indicate briefly the main operations followed in the general process. More detailed descriptions of the extraction processes, illustrated by diagrams and photographs, are to be found in several papers and reports[1] which have been published.

Methods Employed

The methods used depend on the fact that the main constituents of natural gas, methane, ethane, and nitrogen, can be liquefied at much higher temperatures than helium. Ethane becomes liquid at − 86°C, methane at − 164°C, and nitrogen at − 196°C. Consequently, the helium which is only liquefied at − 269°C, can be pumped off in a gaseous state after the other gases have been liquefied.

An analogous process is the separation of argon and neon from the air which is sometimes carried out in conjunction with the preparation of oxygen from the air. This latter process, the recovery of oxygen from the air, is now in common use in all parts of the world and plants are established in almost every large manufacturing centre. The general types of apparatus that might be used and the main lines to be followed were therefore worked out when the first experimental plants for the separation of helium were planned.

Outline of Processes

The processes may be divided into five series of operations; compression, purification, liquefaction, rectification, and final purification of the helium.

The natural gas is compressed to pressures, which vary in the different processes, between 500 and 3,000 pounds per square inch; the impurities such as carbon dioxide, water, and traces of heavy oils are removed by treatment with caustic soda solution, calcium chloride, silica gel, or by refrigeration. As the liquefaction and rectification apparatus and particularly the heat exchangers contain many copper tubes of small diameter, subjected to low temperatures, it is essential that every trace of these impurities should be removed to ensure continuous operation of the plant, otherwise they would solidify in these tubes and prevent free passage of the gases. Many improvements in the extraction processes have been mainly concerned with the more efficient removal of impurities.

The compressed, purified gases are then passed through the heat exchangers. These in principle resemble water-tube boilers, being formed of numerous copper tubes concentric with wider tubes, and have as their object the cooling-down of the incoming raw gases by heat exchange with the outgoing cold treated gases coming from the liquefaction and rectification apparatus. The purified natural gas now at a comparatively low temperature requires only the abstraction of a little more heat to have its temperature reduced below the liquefaction point. It is in the means adopted to secure this end that the two main processes differ, for the preparation of oxygen from the air as well as the liquefaction of natural gas for the recovery of helium.

[1] Pollard, Lieut. W. A.: The United States Helium Production Plant, Fort Worth, Texas. U.S. Public Works of the Navy, Bull. No. 31, pp. 13–46, April, 1920.
Moore, R. B.: The Commercial Production of Helium, Ind. and Eng. Chem. Vol. 18, No. 2, pp. 203–211, (1926).
Wicks, Lieutenant Commander Z. W.: Six years with the Navy in Helium Production. Jour. Amer. Soc. Naval Eng., Vol. 37, No. 4, pp. 698–718, Nov., 1925.
McLennan, J. C.: Helium, its Production and Uses. Trans. Jour. Chem. Soc., Vol. 117, pp. 923–947, July, 1920.

In the Linde process[1] advantage is taken of the Joule-Thomson effect, the fact that gas at a high pressure allowed to expand to a lower pressure through an orifice loses heat. In the Linde process, therefore, the natural gas, compressed to a pressure of 2,000 to 3,000 pounds per square inch and already cold because of its passage through heat exchangers, is allowed to expand through a valve to a lower pressure and in consequence has its temperature so reduced that much of it liquefies.

In the Claude process[1] which does not require such a high initial pressure the gases are cooled to the liquefaction point by allowing a certain proportion to do work in an expansion engine. In either case the desired result is obtained, that is the greater part of the hydrocarbon gases liquefy in the lowest compartment of the liquefaction and rectification column as the apparatus, usually built in one unit together with the heat exchangers, is commonly called.

The column is divided into several sections, each compartment of which is fitted with series of vertical tubes which the unliquefied gases from the lower section ascend. Arrangement is made for surrounding these tubes with the various liquid fractions of the condensed gases, mostly liquid methane and liquid nitrogen, so that a progressively lower temperature is attained and finally only a certain amount of nitrogen and the helium remain in the gaseous state. The cold gases evaporating from the baths of liquid methane and liquid nitrogen pass out through the heat exchangers, cooling the incoming gases and themselves being warmed to atmospheric temperature. The final helium-nitrogen mixture is subjected to a further cooling by a bath of liquid nitrogen under reduced pressure or by some other means. Finally helium can be obtained from 70 to 95 per cent pure, depending on the efficiency of the process.

Practically no natural gas is used up in the process and it is returned to gas mains for subsequent industrial or domestic use entirely unchanged except for the removal of the small content of helium.

Research on Helium Extraction Processes

Although the helium extraction processes closely resemble the well-known methods for the liquefaction and separation of oxygen from the air, the conditions of temperature and pressure to be employed, the solubility of helium in the various liquid hydrocarbon and nitrogen mixtures, the best design of apparatus, have all required much research in order that the highest efficiency of extraction might be obtained. Many scientific investigations of fundamental importance have been carried out by the United States Bureau of Mines and Bureau of Standards, few of which have been made public.

PURIFICATION PROCESSES

Owing to the leakage of air through the material of the gas bags in an airship it becomes necessary after a time to renew the gas. In the case of hydrogen it is discarded and replaced by a new supply. Helium is too valuable to be lost in this way and methods for repurifying it have been developed by the United States Bureau of Mines in co-operation with the Army and Navy authorities. Two methods have been adopted. In the

[1] For a general description of these processes for the production of liquid air and oxygen *see*—
Claude: Liquid Air, Oxygen and Nitrogen, published by Churchill, London, 1913.

first, activated charcoal has been used which when cooled to a low temperature, absorbs all the impurities (chiefly oxygen and nitrogen) but does not retain the helium.

Apparatus have been developed and installed in railroad cars, consisting of batteries of tubes containing charcoal together with the necessary liquid air plant, compressors, valves and connexions, so that a set of charcoal tubes can be cooled to about − 120°C, and the impure gas circulated until the charcoal has become saturated with nitrogen and oxygen. The helium is then put through a second set of tubes. Meanwhile the first set are allowed to warm up and after the impurities are pumped off, the charcoal is again ready for use.

The second method is based on the fact that if the impure helium at a high pressure is cooled to the temperature of liquid air, the oxygen and nitrogen in it will liquefy out. Liquid air is obtained with an ordinary Claude apparatus.

The impure helium compressed to about 1,800 pounds per square inch, after passing through heat exchangers, is circulated through a vessel cooled in liquid air. The impurities liquefy out and pure gaseous helium passes on. Further heat exchangers are used to secure the utmost efficiency. The costs of this operation can be made as low as $2 or $3 per thousand cubic feet.

STORAGE AND TRANSPORTATION

The storage and transportation of helium gave rise to new problems. Hydrogen required for airships is usually generated in a special plant for the purpose at the airship base and can be manufactured as required. For efficient commercial operation helium must be extracted continuously as near to the natural gas field where it is found, as conditions allow. It must then be stored and subsequently transported to the airship station, the location of which is determined by other factors.

The usual method of storing industrial gases was first employed, that is in small steel cylinders at about 1,800 pounds per square inch pressure. But the great number of these required to hold a supply even for an airship of two or three million cubic feet capacity and the inevitable loss during storage through valve leakage rendered this method expensive and unsatisfactory.

After much investigation of the possibilities of storage in gasholders, and in mines, the problem has been successfully solved by the development of high pressure storage in large, steel cylinders. An installation has been built at the United States Naval Air Station at Lakehurst, New Jersey, consisting of steel cylinders, 46 feet long and 4 feet in diameter, made by hollow-forging from solid billets by the Bethlehem Steel Company. Each cylinder holds 65,000 cubic feet measured at air temperature and atmospheric pressure under a pressure of 2,500 pounds per square inch.

As an extension of this successful method, a special railroad car has been built carrying three similar steel cylinders, 40 feet long and 4 feet 9 inches in diameter, with walls 2 inches thick. When filled with helium to 2,000 pounds per square inch this car has a capacity of 200,000 cubic feet of gas, measured at air temperature and atmospheric pressure. The cost of transportation has been very greatly reduced in this way.

COSTS OF EXTRACTION

It has already been stated that until the development of the production of helium from natural gas, the only method for its production was by the treatment of certain rare minerals containing uranium, and that the cost was approximately about $1,500 per cubic foot.

To-day the lowest cost per thousand cubic feet that has been obtained in the United States helium extraction plant at Fort Worth, Texas, is $24, or 2·4 cents per cubic foot.

A most interesting and valuable account of the operation of the Fort Worth plant and the detailed figures showing the progressive reduction in costs from the initial figure of $500 per thousand cubic feet in May, 1921, down to $65 in January, 1924, followed by gradual improvement in operation and the development of more efficient methods during 1925 until the low figure quoted above was obtained, was recently given before the American Society of Naval Engineers by Lieut. Commander Z. W. Wicks[1], and is a great tribute to the value of co-operation between the scientist and the engineer, and to the ability of the staff which directed and operated the plant.

No plant has been operated in Canada on a sufficiently large scale or for a sufficiently long period to obtain actual costs of production from the natural gases available in Canada. However, from the operations of the small-scale experimental plant in Calgary now under the direction of Mr. J. Patterson in 1919-1920, Prof. J. C. McLennan estimated that helium could be produced on a commercial scale in the Bow Island field for $100 per thousand cubic feet.

The cost of extraction depends on a number of factors, the chief of which is the helium content of the gas under treatment. Unfortunately, with one exception, there are no large supplies of natural gas available in Canada with as high a helium content as the United States commercial sources possess. Also there are no centres of population near the richest Canadian helium-bearing gases that could consume the large quantities of natural gas that would have to be treated to secure the minimum of operation costs.

The Canadian gases differ in composition from the United States gases that are at present treated, as they contain a much larger proportion of methane and much less nitrogen. What effect this would have on the processes of extraction, particularly on the costs of operation, is not known.

[1] Wicks, Z. W.: Six Years with the Navy in Helium Production, Jour. Amer. Soc. Naval Eng., Vol. 371, No. 4 (Nov., 1925.)

BIBLIOGRAPHY OF HELIUM RESOURCES AND PRODUCTION

Canada

Elworthy, R. T. Helium in Canada, Can. Min. Jour., vol. 45, p. 1233, 1919.

McLennan, J. C. Report on some Sources of Helium in the British Empire, Mines Branch, Dept. of Mines, Canada, Rept. 522 (1920).

Helium, its Production and Uses. Trans. Journ. Chem. Soc. Lond., Vol. 117, pp. 923-947, (1920).

United States

Bottom, R. R. Helium Sources and Extraction Processes, Oil and Gas Jour., vol. 23, No. 26A, p. 20, Nov. 20, 1924. (History of development, large section on resources, brief description of Linde plant and costs).

Moore, R. B. Helium, a National Asset, Mining and Metallurgy, vol. 4, p. 426, 1923. (General summary of helium situation in U. S. to end of 1923).

Commercial Production of Helium, Indust. and Eng. Chem., vol. 18, pp. 198-211 (Feb., 1926.) (Most recent account of development).

Pollard, W. A. The United States Helium Production Plant at Fort Worth, Texas, Bull. 31, April, 1920, Public Works of the Navy. (Plans and estimates of costs of establishment of the Fort Worth plant).

Rogers, G. S. Helium-bearing Natural Gas, U. S. Geological Survey, Professional Paper 121, 1921. (Account of survey of gas fields and chemical and geological relations up to 1921).

Wicks, Z. W. The Importance of Helium to the Petroleum Industry in the United States, Natural Gas, vol. 6, pp. 10-13, (Jan., 1925). (General summary of history of production, development and resources.)

Six Years with the Navy in Helium Production, Jour. Amer. Soc. Naval Eng., vol. 37, No. 4, Nov., 1925. (Full details of costs of operation).

— — Chemical and Metallurgical Engineering, vol. 30, No. 18, p. 696, May 5th, 1924. (Leader on progress in helium production in U. S.)

USE IN AIRSHIPS

Cole, A. P. Principles of Rigid Airship Construction, Aero. Jour., pp. 97-131, March 1925.

Crocco, C. A. The Use of Helium in Dirigibles, Int. Aeronautics, vol. 1, pp. 214-215, Nov., 1923.

Pritchard. Rigid Airships and Their Development, Aero. Jour., p. 143, April 1920.

Rogers, G. S. Helium, the New Balloon Gas, Nat. Geog. Mag., vol. 35, p. 441, May, 1919.

Wood, J. B. Seeing America from the Shenandoah, Nat. Geog. Mag., vol. 47, Jan., 1925.

— — Helium — Safety and Conservation, Indust. and Eng. Chem., vol. 16, p. 883, 1924.

— — Helium and Helium-filled Airships, Min. and Met., vol. 6, pp. 458-464, Sept., 1925 (illustrated).

— — Helium-filled Airships, Nature, vol. 113, pp. 313-314, 1924.

— — Comparison of American and New British Ships, Sci. Amer., p. 124, Feb., 1925.

GENERAL

Moore, R. B. The Properties, Occurrence, and Production of Helium, Jour. Frank. Inst., vol. 191, pp. 145-199, Feb., 1921.

Weaver, E. H. Bibliography of Literature on Helium to 1919, U. S. Bur. of Stand., Circular No. 81, 1919.

CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN McLEISH, DIRECTOR

1926

Base map from plates of the Chief Geographer Department of the Interior

MAP SHOWING MAIN GAS FIELDS AND PIPE LINES IN ALBERTA

Accompanying report No. 679 on "Helium in Canada" by Dr. R. T. Elworthy

Scale of Miles

25 0 25 50 75 100

Canada

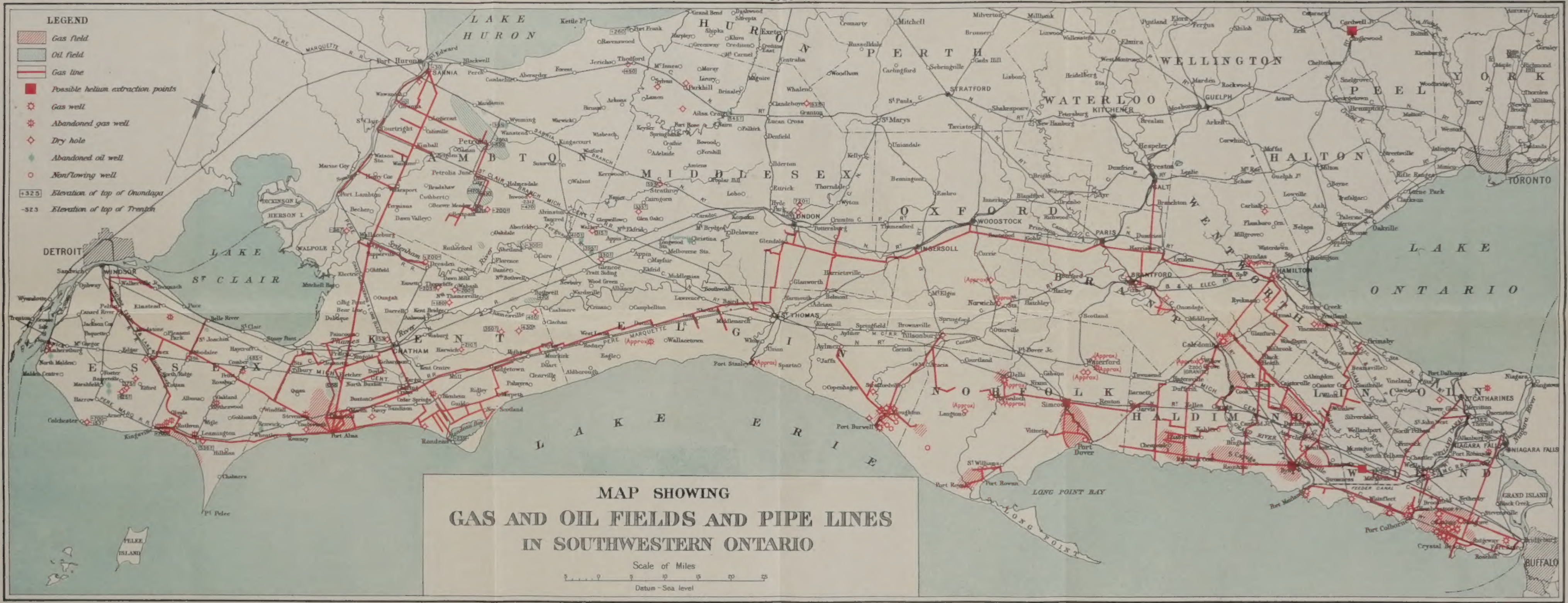
DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN McLEISH, DIRECTOR

1926



Accompanying report No. 679 on "Helium in Canada" by Dr. R. T. Elworthy.